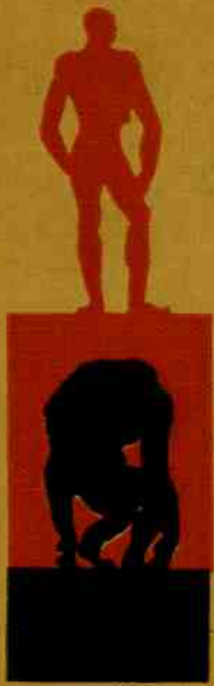


Mildred Thompson

from

her devoted friend

A.T.Q.

March 29th 1930.

THE MASTER OF DESTINY

BOOKS BY

FREDERICK TILNEY

THE BRAIN FROM APE TO MAN

IN COLLABORATION WITH

HENRY ALSOP RILEY

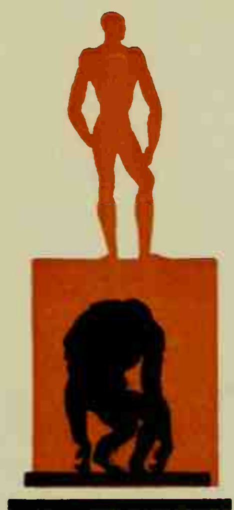
THE FORM AND FUNCTIONS OF THE CENTRAL NERVOUS SYSTEM

THE MASTER OF DESTINY

A BIOGRAPHY OF THE BRAIN

BY FREDERICK TILNEY, M.D.

WITH A FOREWORD BY AUSTEN FOX RIGGS, M.D.



DOUBLEDAY, DORAN & COMPANY, INC.
GARDEN CITY MCMXXX NEW YORK

PRINTED IN THE UNITED STATES AT
THE COUNTRY LIFE PRESS
GARDEN CITY, N. Y.

FIRST EDITION

FOREWORD

RACE after race of man has appeared on this earth, lasted but a short span of time, and then met disaster and extinction. Our modern race is of this series. We have reason to believe that it differs in quality from its forerunners chiefly in its cerebral endowment. That its progress from animalhood to civilization is due to this endowment, is not questioned, for its victory over environment, its ascendency over all other animals is plainly due to its superior brain power.

How did this race originate? Like all the other races preceding it? Or by some aberrant, instantaneous freak of creation? How did it acquire its characteristic brain? As the bird its wings, as the elephant its trunk, as the camel its hump, or by a divine act of separate and special creation? Those who maintain the quarrel over man's origin are not those who have familiarized themselves with the history of the world and its creatures; they are not the astronomers, the geologists, the biologists, the anthropologists or the archeologists. They are clearly those who prefer believing to thinking, the traditionalists, good men mayhap but not necessarily wise. In the earlier days of science (it is only four or five hundred years old), its devoted labourers were persecuted by Church and

State. They had to give respectful attention to criticism or else perish by fire and sword. But, as we have advanced slowly from religious persecution and the auto-da-fé to mere intolerant and wordy remonstrance, the scientist has paid but scant attention to these quarrels. He feels that as they are not of his making, neither are they his concern. Perhaps he is not quite right there. To be sure, he is criticized, not wisely but too well, and for the most part not quite fairly. We have criticized him for an assumed lack of reverence, but even more for his obvious indifference to our criticism. This has justice in it for, though his indifference to criticism may be excused, the ignorance upon which this criticism is founded should be his first concern, for the man of science is the teacher and ignorance is his very opportunity. Heretofore, however, he has seen his opportunity too narrowly, for he has been content to teach only the few embryo scientists apprenticed to his own particular field. He has not, until very lately, realized that his hard-won knowledge is far more needed and therefore far more owed to those who are most ignorant of it, in short, to the great mass of men and women outside the scientific world.

"You are irreligious," said his critics. "You have been weighed and found wanting in that devotional attitude we find essential to humanity. You do not even listen to our reproaches. You are irreverent!"

For the most part, there has been no answer. The men of science have been strangely preoccupied with their own business of finding out all they can of their fellow man, of his nature, his origin, his difficulties, his dangers, and of his predictable future, all in the faith that such knowledge will ultimately benefit mankind.

Now at length one of them has made rejoinder to these protests. He admits that he has been preoccupied, especially so in the past twenty years, with laborious but fascinating research into just these questions so vitally concerning his fellow man. He admits that he had not thought his scientific gleanings would interest any but scientists, but he denies irreverence and insists that neither he nor any other who spends his life in studying man and his place in nature could lack reverence. He cannot find himself entirely in accord with any of the eleven surviving religions which guide the lives of many men to-day. The twelve extinct religions of the past also leave him unsatisfied. Nevertheless he worships devoutly, though in a temple transcending in significance and beauty any wrought by the hand of man. His devotion is no mere lip service expressive of the self-protective instinct, but one that takes form in labour. In spite of disappointment and hardship, he has persevered through years in that labour, with the single object of gaining a deeper understanding of man and his place in nature.

It is now our turn to admit error and ask if we may not share in the fruits of his research—even though our understanding has thus far been alien to his field of labour, even though our path has not led us to his temple, even though we have not been aware of his devotion. We urge him to speak to us, not as to scientists, but as to his fellow creatures, fellow citizens and fellow sufferers. We urge him to speak to us plainly, believing that whatsoever has value in human knowledge may be simply told.

With some hesitation he has consented. He has chosen to speak to us of the brain, as the most direct approach to the comprehension of the nature of man. He points out that this master organ of life holds the secret of human success, that its function is human progress, its neglect human disaster.

The immensity of the retrospect of his story will create in us the wholesome effect called humility. The prospect he pictures is fraught with the terror of what may happen, but it also holds forth inspiration to courage and is golden with hope. No man can follow this account without being inspired by a vision of the dawning of a new era of progress, not an era of greater possessions but of better use of those already possessed; of better relations between peoples and races; and being sobered by a realization that this hope lies in developing still further the efficiency of the master organ of destiny, through training and education.

The scientist speaks. He tells what he has seen and heard and read through the long pilgrimage of years, searching for the truth, and he gives us the fruit of these labours, simply and accurately. But scientific accuracy and matters of fact are only his raw material. They are woven into the fabric of a true story, vibrant with adventure, warmed by the love and reverence of the humanitarian, and illumined by the prophetic imagination of a poet.

This tale of man's emergence is fascinating, inspiring, stimulating, but when it brings us to the climax of the present it becomes a challenge. We are faced by an awful question. Shall the glorious race of modern man sink into oblivion, as all the preceding races have sunk, or may he save himself from chaotic ruin? If he is to be spared for further progress to greater heights of happiness, he must take heed of his own history, he must value his forebrain as his master organ and set himself diligently to develop its powers more fully than ever before. To this end he must discard the last bit of fundamentalism, and the false security of all superstition; he must learn to depend courageously on his own power to understand and control himself; he must give up superhuman sanctions for evils that his intelligence has long since discarded. Knowledge must replace superstition—else the embattled hosts of the world will again be at their bloody work of extinction, praying to the same god, using the same old prayers. It is only by increasing the scope of his forebrain through self-knowledge, training, and education that man can save himself from the old pitfalls from which neither the old nor the new religions have heretofore saved him. It is only thus, through understanding, that he can ever hope to make full use of the forces of growth and change which we call evolution. But our scientist gives us reason to hope that through intelligence, itself a product of evolution, man may yet not only escape destruction by these forces but may even go far toward gaining a mastery over them which will insure the progress of his race toward planes of usefulness and happiness as yet undreamed of.

It is indeed time that we think of ourselves as men in the making and cease to consider ourselves as gods and the lords of a finished creation.

AUSTEN FOX RIGGS.

Stockbridge, Massachusetts,
October, 1929.

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THE MASTER OF DESTINY

CHAPTER I

PRIMITIVE ANCESTORS

ORIGIN AND EARLY DAYS OF THE BRAIN

SINCE every well-arranged biography should start at the beginning, we may first inquire into the origin of the brain. The early history of such an important organ must be closely interwoven with the genesis of man. If man were the result of a separate creative miracle, so also was his brain.

But we are not obliged to accept this view which attributes the universe and all living things to creative miracles. There is another and equally reasonable possibility. We may, for example, assume that man and all else came into existence by that process of continuous change and progressive development called evolution. We have excellent grounds for accepting such an assumption. Astronomy, geology, biology, chemistry, and all of the sciences relating to mankind have revealed the essential facts. Any other interpretation must disregard or repudiate this convincing record. With such a record as this to guide us we may turn our attention to the origin of the brain.

Earliest Forms of Animal Life

The inception of life on our planet was simple in the extreme. The earliest animals, although well organized, possessed no special organs in the strict sense. In the beginning there was nothing which could be specifically called a stomach or a heart, a lung or a kidney. Certainly there was nothing even remotely resembling a brain. The business of living was transacted within a single cell. This cell was so small that it could not be seen by the naked eye. Each of these cells was sufficient unto itself. Each played its own separate part with a simple programme of existence. Each was required to get its own food, to carry on its own chemical activities of digestion and elimination. Finally, after it had been successful in this remarkable process, it was called upon to produce offspring, to perpetuate its species. This last act was the crown and climax of its life, for in this way it conferred a material immortality upon its kind.

The amœba, among living animals, is a good example of this simple life. It is wholly intent upon carrying on within itself the earliest traditions of existence. All of its life is conducted within a single microscopic cell, which is at once its office and workshop. It has nothing in its make-up that could in the ordinary sense be called an organ. In such amœban animals as these there seems to be nothing progressive, nothing to suggest the possibilities of further advancement. Each amœba might, if such a thing were possible, look back over a long line of ancestors exactly like itself. In looking forward it might see no great possibility of progress. Perhaps it might reach the more specialized conditions of its present-day relatives with contractile threads in their substance and vibrating hairs by which to move themselves about. At best the outlook of the amœba for progress was restricted within very narrow limits.

Familiar Animals of Earliest Type

Certain events in the long history of these little animals have acquired much human interest. At times some of these simple lives become strikingly dramatic. Their monotonous existence is changed and they pass through certain exciting phases. Such a drama is often enacted when certain amœbæ gain entrance into the body of another animal and there become parasites. The other animal may be some huge beast or even man himself. One unpretentious amœba (*Amœba histolytica*), if it gains entrance into the intestinal tract of man, may cause amœbic dysentery and abscess of the liver. Another single cell animal (*Trypanosome Gambiense*) living in the blood of certain cattle is often conveyed by the tsetse fly to human blood where it produces the fatal disease known as "African sleeping sickness." This small animal claims hundreds of thousands of victims a year. In tropical Africa its devastations go on unchecked over an area of more than a million square miles. In this region sleeping sickness kills as many persons as all other diseases combined. From five to seventy per cent. of the inhabitants in different localities are stricken. Cattle, horses, and other domestic animals cannot be kept because of this disease. On this account, and also because the area in which the sickness rages is extremely fertile, it has been said that the conquering of this malignant protozoan would be equivalent to the discovery of a new continent.

Even better known are the several acts in the cycle of the *plasmodium malaria*. This protozoan animal is often borne by the Anopheles mosquito and injected into the blood of man. Then follows the familiar series of pathological events consisting of chill, fever, and sweat, called malaria. In certain respects it seems like retributive justice when this animal is injected into the body of man to cure the effects produced by another microörganism. The other organism is the spirochæte which causes syphilis. It often produces changes which destroy the human brain in consequence of a disease known as paresis. Many other protozoan animals are parasites, but in the main they live and have lived simple, unobtrusive lives.

Notwithstanding their apparent simplicity of structure and action, these minute animals, like all other things, have been subject to the influence of continuous change. They have responded to this influence in different ways. In many instances, through generations of reproduction, they have effected combinations and recombinations of their essential constituents out of which have emerged modifications of their original structure. Often these changes have proved progressive and contributed to more complex modes of living. Often they have been regressive or non-progressive. It was the progressive modifications in these earliest animals that were of utmost importance to the origin of the brain. This organ was not yet in sight, but adaptations working toward it were soon to appear.

Critical Changes in Animal Existence

In the course of time certain critical changes took place in the lowly scheme of animal existence. These were distinctly progressive changes. Some of the single-cell animals began to live in colonies. Circumstances thus conferred upon them a community life. They began to exist in close contact with others like themselves and were compelled to forego their simple, independent habits. They were, in fact, actually joined to each other by rather slender bonds of their own vital substance—protoplasm. This was an epochal stride forward. It was the first step which led to progress. In some instances it brought about entirely new relations between these animals and the world in which they lived. Now, since these small cells were grouped together as colonies, each individual cell lost much of its own independence. Its interests became, in some degree at least, the interests of the group. If, as a single cell by itself, it had been thoroughly self-contained, now it was necessary for it to follow the needs and inclinations of its neighbours. It was forced to observe the conventions and habits of its colony. This condition of affairs exists in what are known as the colonized protozoans. In addition to the advantages of community life there was another and far more important reason why this new kind of existence was a critical step. It introduced for the first time the principle of differentiation or class distinction. A division of labour was thus made possible. Some of the cells in each group were forced to take up positions on the outer surface of the colony. Others occupied places inside of the group. This arrangement immediately created a distinction between "outer cells" and "inner cells." It was destined to have far-reaching consequences because it established a difference in the responsibilities of two great classes. The outer cells made an immediate and direct contact with the world. They were nearest to the water, to the light, and to all of the outer chemical substances necessary for living. They were like guards and outposts about a camp, defending the colony from adverse influences. They might be likened to the first line of battle in the aggressive struggles for life, acting as foragers and procurers of food. The rôle of the inner cells was different. Their contacts with the world were more indirect and established largely through the outer cells. Their offices were especially confined to the inner workings of the colony. They became the germ cells whose function it was to insure the immortality of the species. This arrangement was a momentous advance in the direction of progress. It was particularly momentous because it laid the foundations upon which all of the great developments in the animal world were to be built. In a certain way, it was also a prophecy, for it foretold the coming of animals that were to follow the protozoans. These newcomers, the metazoans (animals which came after the first forms of animal life), were to possess a body with outer cells engaged chiefly in the efforts of life, while the inner cells would be particularly concerned with the essence of living, such, for example, as digestion, assimilation, and circulation.

This remarkable process of class distinction among cells developed new and useful methods in living. It brought about a division of labour in the business of life. Different parts of the animal now had different obligations to fulfil. Some parts served to move the body about, some were employed in digesting food, some in eliminating waste, some in breathing and circulation, some in reproduction. In the end, this division of labour resulted in the formation of a body made up of many different organs, each having its own particular responsibilities. We may find an excellent example of the very earliest stages of this division of labour in Volvox, one of the colony-forming protozoans. Most of the colonized cells of this minute animal are on the outside, forming a hollow sphere. These cells are equipped with minute hairs or flagellæ which, by their constant motion, keep the animal rolling around in the water like a hollow rubber ball. In this manner it seeks and finds its food, and thus also it may escape when threatened. But all of the cells of Volvox are not on the outside. A number of them are tucked away from the actual surface of the animal. These are the sex cells to which is entrusted the important duty of reproduction.

Early Influences at Work to Form the Brain

Even by this time in the history of the earth, although animal life had been developing for millions of years, there was no sign of anything like a brain.

The forces, however, which would eventually bring such an organ into existence were already at work. Perhaps from this great distance it may be difficult to recognize the exact nature of these forces as they began to act at this particular stage of life. They were present nevertheless, faintly discernible like the first streaks of dawn which precede the sunrise. This figure of speech may seem to imply that in the end the brain was the actual sun destined to rise above the horizon of animal life and ultimately to dominate all progressive achievement. The rest of this biography must prove whether this is an extravagant figure or not. One important influence behind those forces that eventually produced the brain stands out clearly. It seems to have been the direct result of that class distinction among cells which caused such effectual division of labour. With this subtle influence at work it required one further critical step to set in motion the events which were to end in the formation of a brain. This step was taken when the sponges (*Poriphara*), the simplest of metazoan animals, came into existence. They differed from the protozoans, even the colonized protozoans, because their bodies were more complexly organized. The individual cells forming them had lost most of their separate independence. All of these cells were now incorporated in a single living individual, and each cell was subordinate to the interests of the whole.

Cell distinction had become still more important because of the increase in size of these animals. The outer cells now formed a covering or skin called the "ectoderm." The inner cells constituted the wall of a cavity, which might be likened to the lining of the stomach. The lining is called the "entoderm." Many minute openings or pores in the outer covering established communication by means of small canals with the inner cavity of the animal. Through these pores water is inhaled and carries with it particles of food into the inner chambers. These particles are absorbed, and the water is then exhaled through a larger opening called the "osculum."

It was at this critical point that a decisive factor leading to the formation of the brain made its appearance. Some of the deep cells around the pores and outlets of the sponge formed "muscles." In many respects this was a new device, and the sponges become especially interesting because of this innovation in animal life. The innovation itself resulted in a special machine for producing motion; namely, the muscle cell. Such muscle cells in the sponge are extremely simple. They form rings around the pores and the outlets which, by contracting, regulate the flow of water through the animal. But such muscle action as this is extremely important because if the water in the sponge contains an abundance of food particles, muscular contraction prevents too rapid outflow. This slowing of the ex-current stream, among other things, allows more time for absorption and digestion. The muscles in different parts of the sponge act independently. Each one is, so to speak, a free agent, occupying its position at its own particular pore or outlet. If, however, it became necessary for all of these muscles to contract at the same instant in a concerted effort, let us say, to make the sponge move, there would be no mechanism to assure harmony of action. The muscle cells at each outlet would react according to their own inclinations—some relaxing, others contracting. Confusion of action could scarcely fail to result. The sponge, however, does not need to move about in order to get its food. Being stationary, it obtains its nourishment by sucking the water through its pores, and by regulating the flow the muscle cells do all that is required of them.

A New Motor Device

Simple as is this muscular equipment, it possesses great possibilities for further development. It clearly indicates how such mechanisms for producing motion might be expanded to create all of the surprising varieties of motors which in time enabled animals to move about over the earth, in the water, and through the air. It is true that the simple strands of muscle in the sponge are far from powerful; but when a number of muscular strands are collected together they may take form in such muscles as the biceps of the arm, the great extensors of the leg, or those covering the entire body.

The presence of the muscle cells created the need for a nervous system to control and regulate their activities. In order to act together muscles require a supervisor. The first important step in this direction was taken when certain simple animals like hydras and sea anemones (*Metridium*) made their appearance. These animals are equipped with muscles in several parts of their bodies. Some of them, unlike the sponges, have the power to move about a little, crawling slowly like snails. They are also capable of moving their many tentacles, and thus are able to reach out and grasp food. All of these movements call for the action of the many different muscles. The sea anemone has thirteen different sets of such muscles, the exact coöperation of which requires the closest harmony of action. Each part must be mutually adjusted to the others. It must act in the right rhythm and with the proper force. Such delicate adjustment as this could not be left to chance. It needed an adjuster and regulator. It required also a system of communication between the cells in order that each might sense how the others were acting during any given interval of time. In consequence of these requirements many cells were specialized as timers, signallers, and dispatchers. They acted like independent telephone stations, each serving separate districts; such, for example, as the individual tentacles of hydra or of sea anemones. These separate stations were known as nerve cells. *In them the first elements needed for the origin of the brain made their appearance.* At first they were scattered and had limited communication by means of slender strands, the nerve fibres. There was as yet no central operator for receiving and routing their messages which were transmitted rather diffusely by a loose nerve net.

Foundation Stones of the Brain

In spite of this apparent simplicity, these nerve cells were the foundation stones of the brain. Scattered as they were, they lacked that unity of action which is the real secret of nerve power. A more constructive plan for utilizing their capacity was requisite at this stage. Such a plan was eventually forthcoming. It was exactly what might have been expected in the progressive development of any good business concern; namely, consolidation. In effect, it was a merger uniting the separate nerve units into one centralized system. How this merger was brought about may be recognized in such animals as the jellyfish (*Cœlenterates*). In them the body equipment consists of an outside layer called the "exumbrella," and an inner layer, the "subumbrella." In the latter the older arrangement of the nerve cells as scattered, more or less independent stations still persists. These stations form a net of communication on the under surface of the animal. But where the subumbrella joins the exumbrella, making the rim of the jellyfish, the nerve fibres and the nerve cells form a nervous ring entirely surrounding the animal. This is the first time in the history of animal life that an actual central nervous system makes its appearance. This ring of nerve fibres and cells acts as a central receiving and dispatching station. It is a central office for receiving information from the outside world and a dispatcher for sending orders to different portions of the animal so that all parts may coöperate harmoniously. Certain special organs develop along the rim of the jellyfish, whose functions have some bearing upon the sense of direction. These structures are known as the marginal sense organs or "lithocysts." They are in direct communication with the central nervous system. Certain other sense organs are also present in the form of red or black specks of pigment at the bases of the tentacles; they are the "ocelli," which are sensitive to light and are, in fact, the simplest form of eyes. Thus, in such low forms of animal life as the jellyfish, the first signs of special sense organs made their appearance, and the nervous elements were for the first time organized to form a central governing mechanism for the animal.

Nerve Concentration in Forming the Head

Following the merger of the scattered nerve cells to form a central system, the process of developing a brain had opportunity to advance along another new line. The circular nervous system of the jellyfish passed through many modifications as it adapted itself to the form of different types of lowly animals. The great impulse thus imparted toward the formation of the brain veered off in numerous directions until a new and decisive change occurred in the arrangement of the muscles. At this juncture certain animals appeared whose bodies were much elongated and slender. Their muscles were arranged in straight rows, one behind the other. Such an arrangement had definite advantages for transportation, and these advantages were utilized by such animals as the flat worms (*Platyhelminthes*). Many of the nerve cells and fibres became concentrated in the head end of these animals. This head region in a general way took the lead in directing the activities of motion and transportation. It also had centralized in and about it many of the most important structures of life. The animal at this critical stage now possessed a head and a body. In the broadest sense the development of such a head may be likened to the creation of a definite executive office within which was established a supreme organ to preside over the rest of the body.

Further concentration of nerve cells in the head of the animal was the next step in this constructive process. This advance added materially to the centralization of nerve power, which was the keynote in the formation and growth of the brain.

If this process of successive upbuilding seems mysterious and almost miraculous, especially from its feeble beginnings in a single cell, it is scarcely more remarkable than the commonplace miracle that has resulted in the development and birth of every newly created animal since the dawn of time. The offspring of each species—fish or fowl, beast or man—has its beginning in a single cell. It passes through stages of cell colonization, of class distinction among cells, and of specialization of organs for the various functions of life.

In the main, these two processes have run parallel in their programmes of construction—the beginning and development of life on our planet, the beginning and growth of every new life created. Summarized thus briefly, these successive stages necessary to bring the brain into existence may appear unimpressive. But when we consider that each forward step required ages for its achievement, we may appreciate that this was indeed a marvel of progress. From nerve cell to brain is a few short words in print; but it required millions of years for the slow advances to attain even the humble level of the flat worms.

Development of Better Brains

With the head at length in its proper place and the most simple kind of brain installed within it, vast horizons of life still lay ahead. Better mechanisms were needed for a more successful struggle with existence. More capable motors were required for more efficient locomotion. These improvements came after the passage of long intervals of time. By degrees more highly developed animals, such as bees, ants, beetles, or other insects, lobsters, crayfish, and shrimp, began to appear. Their brains were much better organized than those of the lowly worms. The special senses of sight, smell, and taste became highly important, while the central organ which presided over all activities acquired a remarkable complexity in its structure.

How much these animals gained from their better brain power is clearly seen in their behaviour. The achievements of ants and bees and beetles, as well as many other insects, have long been a matter of wonder, a theme of interest and fascination. If we credit these animals with highly capable brains, it is their just due. One detail in their organization, however, became a serious handicap to them in their further development. The passageway from the mouth to the stomach ran directly through the centre of the brain. If the brain grew extensively it would encroach upon the gullet, ultimately shutting off the only channel for food. This embarrassment actually overtook many insects like the mosquito. Here the brain became large. The tube connecting the mouth and the stomach was thus reduced to a fine calibre, and the animal was forced to depend upon the highly concentrated fluid diet obtained by sucking blood. Coarser forms of food could not pass the œsophageal ring which the brain forms about the gullet. Thus the stomach and the brain came into serious competition with each other. If the brain grew larger the stomach would be deprived of food. In consequence, this situation created a dangerous hazard to life.

Advent of Backboned Animals

In addition to this stomach-brain dilemma, animals such as the insects suffered from another handicap because of the outer skeleton which protected their bodies. This skeleton was in the form of a more or less rigid shell, as in the lobster, crab, or crayfish. It was to overcome the effects of such handicaps, according to some authorities, that the great race of backboned animals came into existence. In any event, such animals seem to have circumvented the difficulty of having a brain which surrounded the gullet. They also overcame the necessity of carrying a heavy shell about on the outside of their bodies. An inner skeleton did away with this embarrassment. It is not altogether clear how or when this transition took place. Many students of this matter believe that the basis for this change is to be found in the starfish group of lower animals (*Echinoderms*). Others maintain that the change began with some creature not unlike the horseshoe crab (*Limulus*). It is also believed that the animals which served as the intermediate forms for this advance were the ostracoderms, a group which has long since become extinct. They are known to us only through fossil preservations. They possessed, however, so many fishlike features that they may well have served as the forerunners of the earliest animals with backbones. Whatever else is in doubt, one detail of this transition is definite. The brain, already well developed in certain lower creatures, now received a fuller opportunity to advance along more advantageous lines. The first gains of this kind are seen in the fish. Judged by outward appearances the object of such new brain development was to provide a more efficient regulator for a new and more efficient kind of animal. The fish, in one particular at least, showed higher specialization. It was built for speed in locomotion. The shape of its body, the arrangement of its muscles, the position of its fins, the design of its head, and the form of its tail gave it many advantages over lower animals. Equally important were the special organs by which it sensed the world. The fish possessed powerful and remarkably constructed eyes. It had most delicate organs for smell, and an effective apparatus for taste. In fact, all of the senses of the body were now so thoroughly organized that each one of them had its own special department in the brain. According to this new type of administrative organization, an endbrain, an interbrain, a midbrain, and a hindbrain were established for distinct departmental purposes.

In spite of this better arrangement, there were still decided limitations in the brain. The most serious of these deficiencies lay in the mechanism regulating the energy turnover. The fish had little power to withhold its reactions. Its impressions from the outside world produced almost immediate responses. Such rapid reactions precluded the wide range of acts which characterizes more deliberate behaviour.

The brain machinery for the most ample kind of living was not yet present at this stage of animal development. It did begin to make its appearance, however, when certain of the fish assumed partial adjustment to life on land. These adventurous pioneers managed to crawl out of the muddy waters at times when there was a lack of oxygen or when the supply of food was insufficient. They set on foot those progressive changes that gave rise to fore and hind limbs in such amphibians as the frogs. When these latter animals made their appearance nearly all of the fundamental problems of the vertebrate brain had been solved. Nevertheless, there was still the need of certain expansions in brain power and these, in some part, were supplied during the age of reptiles.

As yet, however, that handicap of almost instantaneous reaction which seriously limited the life of fish had not been entirely overcome by the amphibian or by the reptile. These animals still lacked the brain mechanisms needed for the deliberate and varied actions of the most efficient life. They had not yet altogether escaped from the ancient tyranny of automatic or reflex reaction.

At length the mammals, throughout the different periods of their long progressive age, introduced the final detail of brain perfection. The secret of this perfecting detail was the addition of a new mechanism to the brain never possessed by animals before this time. The great and new areas of the cerebral hemispheres now came slowly into existence. With them developed new and greater capacities for action together with far more effective adjustments to life.

Vast Ages of Animal Life

All of these developments reach back a great distance in time, so great that it is difficult to calculate its exact duration. According to modern estimates the first animals came into existence about 1,000,000,000 years ago in the Proterozoic period. This period was followed by the Palæozoic, which began approximately 300,000,000 years ago, and is known as the Age of Fish. Then came the remarkable Age of Reptiles, beginning about 200,000,000 years ago, followed by the Age of Mammals, which commenced in the neighbourhood of 65,000,000 years ago. The present Age of Man has had a short duration, extending back only about 1,000,000 years.

Two methods have been depended upon in determining these figures and the age of the earth. The first is based upon the rate of deposit and upbuilding of sedimentary rocks. The estimated period required for the development of each rock layer has provided a time-table for the age of the different strata of the earth's crust. The second method calculates the rate at which common salt is extracted from the land and deposited in the oceans. Imprints of fossil animals upon the several rock layers also reveal the age of different strata. The discovery of radium afforded the latest gauge for estimating geologic time. The physicists now tell us that former calculations have been far too modest and that we must go back still further to reach the actual beginnings of our earth. Their "radioactive clock" indicates that the earth is 1,600,000,000 years old.

During all this vast interval there has been a succession of great changes in the earth and its waters. Continents have risen above sea level, to be submerged again. Great inundations of continental oceans have swept inward and made vastly different land divisions from those which exist to-day. North America has been more or less widely flooded by great oceans at least fifteen times. Other continents have been similarly inundated. Mountain ranges have risen and crumbled away by erosion. In point of geologic time most of the present mountains are relatively young. The oldest of these is the Appalachian range which was formed during the Permian period approximately 230,000,000 years ago. The Rocky Mountains appeared at the close of the Cretaceous, 100,000,000 years ago, while the Swiss Alps are of much later development, having been formed at the close of the Miocene about 15,000,000 years ago. Even the Himalayas are relatively young when compared with the earth's antiquity. They had not taken on their full gigantic proportions until the close of the Eocene about 45,000,000 years ago.

According to many authorities, great continental land connections once existed between Africa and what is now part of South America. This connecting continent disappeared beneath the ocean long ago. So also did the land connection between Asia and North America in the region of the Bering Sea. An important land connection existed between England and the Continent, across what is now the English Channel, in Pliocene times. It was present, therefore, at some time within the last 6,000,000 years. Immense inland seas have drained off or evaporated and left in their places great desert spaces, like the Bad Lands of the West.

The Long Upward March Toward Humanity

While these changes were in process marked alterations in climate affected the surface of the earth. Glacial ice caps descended from the poles, later to recede and leave the earth invested in tropical warmth. Time and again these changes recurred. The crust of the earth, chilled by intense refrigeration for protracted ages, grew warm again for equally long periods when tropical vegetation crept up toward the poles. These changes in vegetation have been accompanied by many changes in the animal inhabitants of the globe. Species of animals in profusion have come into existence only to follow the path which led to extinction. In many cases the forms of life began simply and progressed by graded stages to greater structural complexity. Man is an outstanding example of this rule. He began in much simpler form than that in which he now exists. This relative simplicity is particularly true of his brain.

Thus, as if descending a long stairway, we may pass by the successive terraces of the earth's history toward the beginnings of geologic time. The expanse of this time is difficult to conceive. From the inception of animal life in the long Proterozoic Age, throughout the ages of Fish, Reptiles, and Mammals, man's brain was in the making. Irresistible forces molded the various stages of its progress. Species, genera, families, and even entire orders of animals came into existence and disappeared as wastage in a great experiment. Yet, through all vicissitudes of time and change, the long upward march toward humanity held its place. Ultimately it became the dominant feature in creation. The advent of man introduced a new era. It remains to be seen whither the forces moving in this Age of Man will take us. They may be leading to extinction. The way to such a termination is clearly open to our race. On the other hand, the brain has made man what he is and may save him for better things. Its interesting pioneer ancestry, although extremely remote, has left a well-established record. The history of its development through the process of evolution in the backboned animals is still more interesting.

CHAPTER II

ANCESTORS BEFORE THE APES

THE BRAIN FROM FISH TO MAN

Practical Significance of Evolution

THERE are many who still harbour resentment against the ape, especially in explaining man's origin. As a result, hostilities often flare up against evolution. It cannot be denied that the unattractive ape is at the root of these reactions. He is the bar sinister and the real stumbling block in the evolutionary theory. He is also, to many people at least, the entire gist of it. That we are descended from monkeys is rather generally accepted as the meaning of evolution. This view, at best, is a superficial explanation of what evolution really means. No scientist to-day believes that any one of the living apes is ancestral to man. These animals belong to families totally divergent from the human family. They have ascended well up into the trees. Here doubtless they will remain, quite as unconcerned in human origin as they are innocent of participation in it. Our interest in evolution should not centre upon the ape kind. The line of our ancestry reaches far back of them through millions of years. We were in the making long before there were any apes on earth. They, in their tree life, merely afforded the last finishing touches which shaped our course toward humanity. If we wish to acknowledge our hereditary indebtedness properly, we would be compelled to recognize in our family tree that highly important line of mammals which first introduced the custom of arboreal living. Back of them are still older lines which deserve equal ancestral credit. Here are found those animals without the existence of which we should never have arrived. Among these is the vast assortment of reptiles, together with mammal-like reptilians which appeared in the Age of Reptiles. All of these reptilian forms were in their turn indebted for existence to earlier amphibians and fish, their progenitors during the long Age of Fish. Thus the true line of evolutionary descent leads us from fish to man. Not until we appreciate the meaning of this long vertebrate lineage through all its various phases does the vital significance of evolution become clear. If we view it in this way it is possible to sense the irresistible force that has carried animal life onward and upward through the ages from the earliest times. This force may still carry us onward. In its broader applications such a viewpoint should make an urgent appeal for thoughtful consideration. It offers many suggestions concerning further advances and readjustments in human behaviour.

Evidence of Evolution in Our Bodies

The brain is one of the best witnesses testifying to this long evolutionary development of man. It contains convincing evidence of this process in three striking particulars. First, it gives numerous signs indicating its primitive origin from the lowest of the vertebrates, the fish. Second, it bears identifying marks of intimate association with animals of its own class, the mammals. Third, it has a large number of details in its special mechanisms possessed in common with all of the primate order, to which man belongs together with the lemurs, tarsiers, monkeys, and apes. This evidence is not circumstantial. It is direct and unimpeachable. It leaves no point in the line of man's long descent to be decided by inference. It embodies factors which led, step by step, to the upbuilding of the human brain.

Other tissues and organs of the body tell the same story of slow, steady progress upward, from some low and simple phase of life, through many graded stages of improvement until the human form at length came in sight.

The blood has been an especially positive witness concerning this progressive development. Tests with many different kinds of animals show that the blood of man is much nearer to that of the great apes than to the lower Old World monkeys. The relation between the human blood and that of the New World monkeys is still more remote. In general, these blood tests are among the most convincing proofs of evolution.

The bony system of the body is another decisive witness. The skeleton of the fore and hind limbs sheds much light on the changing adjustments which have been made in the motor apparatus. The use of the limbs as fins, paddles, wings, hoofs, paws, claws, hands, or feet, indicates the broad family relations and kinship of various animals. The size and shape of the skull and the character of the teeth reveal the manner in which this evolutionary process has passed through its several stages. The muscular system, the system for eliminating waste products of the body, the heart and the lungs, all afford important evidence of vertebrate kinship and evolution. The increase in the complexity of the breathing apparatus, from the early gill stages of the fish to the lung of the mammal, through all its many intermediate phases, discloses with astonishing clearness the course of this progress.

The Embryo as a Witness

Testimony from another source also stands undisputed. This corroboration comes from the manner in which all vertebrates are conceived and formed. The witness in this case is the embryo, which in all animals begins in the same way. Embryonic existence starts from a single cell. It holds true to the earliest beginnings of animal life that first appeared in a single cell such as the amœba. In the higher animals this cell is called the ovum. From it, after fertilization, two cells are derived, then four, then eight, then sixteen, until it has an appearance closely resembling some of the colonized protozoan animals. Here again, even in man, is seen that decisive stage in which a critical cellular distinction is made between outside and inside cells. From this time specializing progress in the growing individual goes forward. Each new phase repeats in a general way a stage of development previously attained in the evolution of life. All embryos of vertebrate animals pass through such phases. The fish embryo carries the process up to the stage characterized by those improvements which developed during the Age of Fish. The amphibian embryo takes the process one step farther. It adds new features essential to living on land. Embryos of reptiles and of birds introduce the progressive advancements peculiar to their kinds. The mammal embryo takes the final step, prior to which it passes successively through the several phases of the lower grades of life. The human embryo follows the mammalian plan and puts the finishing touches of development upon what the mammal has gained from all the stages below it. Fish, amphibians, reptiles—all have their beginning in a single cell. Regardless of the differences in body form, in mode of life, and in behaviour, all are cast in a mold of development based on a common design. Thus, while the blood, the bony system, the muscles, the teeth, the eliminating system, the heart, and the lungs tell the story of progressive development, the embryo gives a summary of this process by disclosing the general plan which underlies the manner in which every backboned animal is formed.

The brain contains a comprehensive record of this progress. There are reasons why this is the case. Brain influences pervade and dominate all other systems. This organ is the great transformer of energy, which so assembles other parts in operation that the body as a whole becomes a smoothly acting machine. It receives sensory impressions from its environment. It controls the reactions incited by these impressions. In this dual capacity the brain has been especially sensitive to those influences of change and adjustment, of action, reaction, and interaction that have affected animal life during its long existence. It has responded to these changes and has retained the impression of such responses. In many cases it has been structurally improved. Gradually it became capable of sensing the world more effectively. It acquired the capacity to react on a broader scale. Developing along certain progressive lines it has served to transform impressions received from the senses in such a way as to produce an increasingly more effective turnover of nervous energy. For this reason it is necessary for us to estimate the value of such senses as were utilized in this way. Without going too extensively into detail, it may be said that, with extremely few exceptions, vertebrate animals possess four chief varieties of sense. Each of these supplies the brain with stimuli necessary to its proper reaction.

Value of Our Senses

First, chemical sense, through special organs for smell and taste, conveys information concerning certain chemical conditions in the surroundings. The sense of smell derives its impressions from gaseous or volatile substances which, among other things, may create a pleasant or a disagreeable odour important in selecting food. The sense of taste gathers its information from substances in solution. It depends upon acid, sweet, bitter, salty, or other similar stimuli. The primitive headquarters for taste are in the hindbrain, while the endbrain serves in this capacity for the sense of smell.

Second, body sense furnishes information concerning what transpires within the body, as in the heart and lungs, in the stomach and intestines, and in other special organs. It also supplies equally important information concerning what contraction is occurring in the muscles, how the bones are being moved, what postures the different parts are assuming, and how the body as a whole is being balanced.

Third, contact sense makes known what is going on immediately outside the body. It depends upon many things which touch the body surfaces, such as the touch and pressure of a handclasp, the temperature of water upon the hand, the vibration of a heavy vehicle running over the ground. Body and contact senses had their original headquarters in the midbrain and interbrain.

Fourth, distance sense supplies information concerning objects in the world outside of the body more or less remote from it. The information which this sense brings is news from abroad. It is gathered by the sense of sight and the sense of hearing. Sight, in a way, is touch at a distance. When an animal sees its enemy a long way off it, so to speak, touches this enemy with its eyes and thus gives the brain the needed information while there is yet time for escape. Sight depends upon light waves, and hearing upon sound waves. By such means these two highly specialized agents of distance sense gather their information. The central offices of sight and hearing were at first situated in the midbrain.

All impressions obtained from these senses were and still are the raw materials utilized in the energy turnover produced by the brain.

Improvement was not always the result of the great struggle for adjustment. There were many ups and downs, many trials, many failures. Yet a certain insistent tendency toward progress was constantly in evidence. By means not entirely clear, this tendency ultimately succeeded in finding some way to become effective. It appears to have exerted its influence by selecting definite parts of the animal machinery for emphasis or repression.

Often some highly selective improvement was developed in the brain to meet special conditions. Such is the expansion in the bird's brain by which the sense of sight is greatly amplified. This special increase makes it possible for the bird to see its prey from great distances in the air, as the hawk sees the fish in the water, or the vulture detects the presence of carrion by its keen eyesight. The sense of smell in birds is much less developed than vision.

In scenting animals, like the dog, the fox, and the cat, selective improvement has affected the sense of smell. In a few instances the addition of a relatively new sense was the means by which improvement manifested itself. Such an addition is seen in that transition when fish life first began to assume the characters of living upon land. At that juncture the sense of hearing was added in some amphibious animals belonging to the same class as the frog. These and other methods for getting a better supply of raw materials through the senses contributed to progressive development in the brain.

The Sense Combiner

Still more effective was the improvement which came as a new mechanism. It provided a special apparatus that may for convenience be called the "sense combiner." The office of this mechanism was to assemble sense impressions in the brain, to make composite pictures of sight, hearing, taste, smell, and all other senses. This sense combiner served also as an effective depository for impressions already received. It held them in readiness for use as a background of experience that would be needed for new or subsequent situations. At a glance it is evident that the brain having the best sense combiner would outstrip all others in its efficiency and output. In the earliest vertebrates this new mechanism did not acquire a centralized headquarters. Its operations were controlled from several scattered stations in the brain. Obviously such division of responsibility could not be considered an efficient method of control. Centralization was needed, and certain stages in the development of the brain from fish to man illustrate how this improvement was gradually brought about.

The first or fish stage, as might be expected, expresses the beginning of this process of improvement in simplest terms. There are many who do not credit the fish with such a thing as a brain. These animals, however, are equipped with an effective organ of this kind. Its efficiency is not high according to human standards, yet, as we shall presently see, it has many characteristics of the human organ and reacts to similar stimuli.

In the fish brain there are nearly all of the working departments found in man. Much variation exists even among fish. Some of them have very simple brains. This is true of the earliest forms, but the more advanced types acquired brains thoroughly efficient for the special complexities of existence in which they had to live. The several departments in these brains are adjusted to their requirements. The sense of smell in the fish is particularly well developed. It has certain limitations, however, due to the fact that it must depend upon substances borne by the water. The department of this sense, nevertheless, occupies the major portion of what in these descriptions will be called the endbrain. The sense of taste is also well organized in fish. In certain of them, like the catfish, it has received special emphasis, because in addition to taste organs in the mouth there are organs of this kind scattered over the entire body from head to tail. The primitive central office of the sense of taste in fish is located in the hindbrain. Body sense is highly developed because most of the fishes are able to control their muscles and joints in an amazing way as they dart about in the water. Balancing of the body in swimming is another important problem in the locomotion of the fish. It is solved by means of certain highly specialized water levels (semicircular canals). The body sense department occupies the interbrain. The sense of sight in most fish is fairly well advanced, although it has distinct limitations. Being placed on the side of the head, each eye acts more or less independently of the other, and the fish, so to speak, gets a two-eyed picture of its surroundings. It will subsequently become clear that one of the most important events in the progress of the brain has been the development of that kind of vision in which both eyes receive the impression of an object at the same time. Then again, the medium in which the fish lives is in many respects less favourable for the passage of light rays than the air. The retina of the fish's eye which first receives the light rays also indicates a relative simplicity in the organization of vision. For these and other reasons the fish's sense of sight cannot be as effective as in the higher forms of life. This sense department is located in the midbrain.

Starting with the Fish

The fish stage in the development of the brain shows a striking deficiency in its lack of provision for a sense of hearing. Strictly speaking, fish have no ears. It is believed that the ability to hear which the human being possesses is denied to them. In still another respect, however, a more obvious deficiency makes itself apparent. The brain is poorly equipped in mechanisms that could specifically be called sense combiners. Some slight degree of combination between the senses does take place, but this at best is meagre and simple. Consequently the brain's output, that is to say, its productive turnover, is limited. It confines itself to those reaction patterns with which we are familiar in the habits and behaviour of fish. The limitations by which these patterns are restricted are evident in the fact that the animal's entire life programme is carried on largely under water. If an attempt were made to estimate the capabilities of the fish as a machine compared with other animals, it would almost certainly receive a low rating. The justification of this low estimate is obvious. The reasons for it are twofold: first, the relatively low degree of development in each of the sense departments including the lack in one department (sense of hearing); second, the poorly developed sense combiner.

Professor Gregory has devoted much time in the American Museum of Natural History to the study of the progressive stages from fish to man, and especially to those changes which appear in the head. He has shown that in this fish stage the animal at first had no lower jaw and no teeth. Its mouth served as a sucking organ, which thus obtained food in the form of minute organisms and small particles of organic matter. Certain new patterns were introduced with the appearance of primitive sharks. These animals had a lower jaw impregnated with lime salts, thus made effective for supporting many successive rows of formidable teeth. Such sharks also had well-developed gills. Certain lobe-finned fishes of a somewhat later period (*Crossopterygian*) began to live in streams and swamps. By means of their peculiar fins they were able to crawl over the surface of the land, and thus they were the forerunners of the next more completely air-breathing stage determined by the appearance of the amphibians.

The Beginning of Life on Land

The second or amphibian stage came after those steps had been taken which led certain modified forms of fish life to attempt a partial adjustment to living on land and to breathing air. True amphibians then made their appearance. Animals called tetrapods, or four-footed creatures, were the result of this change. They were the forerunners of all higher animals. By the slow conversion of their fins and paddles into legs they acquired a new kind of transportation machinery. With the aid of these four legs the animal could now hop about on land and also swim in the water much as do the frogs. Such a transformation had a profound effect upon the entire body, which became greatly shortened and in many instances no longer possessed a tail (except in the polliwog stage). The head also changed. New devices were necessary for the purposes of air-breathing, which replaced the old method of getting oxygen out of the water. One of the most important changes, however, was the addition of the new sense of hearing. The amphibians, living partly on land, were now able to receive useful information by means of air waves. The advent of this new sense was destined to have momentous effects upon the further development of the brain. Each of the several sense departments is well represented in the frog. The sense of smell is highly organized. It contains some improvements over the fish for the reason that the animal is now able to scent odours borne by the air. The sense of taste shows little if any improvement. Compared with many of the fish it has actually receded. Body sense is well provided for and shows certain refinements due to the fact that it has taken on the new responsibility of sensing four legs. It also has the duty of supervising what is going on in the muscular machine when the animal performs its new kind of motion, hopping about over the ground, leaping into the water, or using the new frog-method of swimming. The department of the sense of sight shows some improvements when contrasted with that of the fish. The frog is able to adjust its vision both to air and water. While on land it is able to see many things that never come into the range of the fish's field of vision. Some of the frogs even go so far as to have what is called a third eye in the middle of the forehead. This organ, however, is but poorly developed and serves more for light perception than for actual seeing. The introduction of the sense of hearing, by establishing certain innovations in the frog brain, provides an advantage over the fish. It is, however, in furthering the development of the sense combiner that the frog's brain shows its most distinctive advance. The two great hemispheres are now clearly outlined. The end-brain, in consequence of land-living and air-breathing, has taken an important step forward. In all further advances this part will bear the chief burdens of progress and improvement.

The frog and his kind represent a machine that in many respects is not much better organized than the fish. But amphibians did serve to introduce advantages that were utilized in new adjustments to life; such, for example, as living on land, breathing air, getting about on four legs, and being able to hear. Besides this, the way was now opened for a better type of sense combiner. There was promise, if not actual profit, in these new amphibian endowments. Professor Gregory has shown that among the most important changes in the amphibian head were those which ultimately led to the formation of the ear. The skin in this region was already beginning to act as a tympanic member or eardrum.

Epoch of Giant Reptiles

The third or reptile stage witnessed that critical advance that came with the fully established habit of living on land. The amphibians, both those which retained and those which lost the tail, took the first somewhat hesitating steps in this direction. They were, however, essential predecessors to the next higher order, the reptiles, which upon their arrival stepped out boldly. During the remarkable Mesozoic period these reptiles covered the earth with their dominating and often hideous presence. No period compares with this one for the awe-inspiring inhabitants that peopled the world. It was then that the gigantic dinosaurs were the overlords of creation. Some of these monstrous creatures were composed of many tons of flesh and bone. They became the most terrific fighting machines ever produced by nature. Even the tail, which had disappeared in many of the amphibians, became prominent as part of the offensive equipment in these reptile monsters. Gigantic size was an outstanding structural feature. But these huge dimensions carried their own penalties. They were extremely hazardous and destined to bring catastrophe. Even if some of the great reptiles might have been thoroughly efficient fighting machines, they lacked the essential advantages of progressive brains and brain power. In this respect they had improved but little. That tremendous monster *Tyrannosaurus rex*, the most destructive engine ever created, had a body weighing many tons, with a brain of less than a pound.

The prolific Mesozoic reptiles inhabited the land and infested the waters of the earth, its oceans and inland seas, its lakes and rivers. They also for the first time attempted to realize the advantages of another mode of life. Having adjusted their weird bodies to the water and to the land, they next took to the air. Late in the Permian or Triassic times (150,000,000 years ago) some lizard-like reptiles, partially biped in habit and distantly related to the great two-legged dinosaurs, assumed habits of life adapted in part to the trees. Specialization of their fore limbs led to wing-like structures for purposes of volplaning to the ground. Such modified fore limbs eventually acquired the character of wings, and thus, according to some authorities, the most ancient of known birds had their origin in the Age of Reptiles. Many students of this subject believe that bird life may have begun at an even earlier period.

More conservative and also far less conspicuous was another tendency which developed in this reptilian age. For a long time it remained most unpretentious. The spectacular development of huge animals for land and sea held the centre of the stage. Mere size, however, is not always sufficient for success and progress. In any event, a certain number of relatively small reptiles began to show changes along entirely different lines. At first it was difficult to discern the signs of progress in them. Slowly, however, significant modifications came about in two important details: First, in the readjustment of the fore and hind legs, so that acting together they began to lift the body of the animal clear off the ground. The second great change was an alteration in the teeth, which were gradually specialized until they assumed the characters recognized in those later animals known as mammals. These two new traits, developed by relatively inconspicuous reptiles, led in time to animals that became the actual forerunners of the mammals. They are known as the pro-mammalian reptiles (*Cynodont*, *Theriodont*).

Reptile Forerunners of the Mammals

It is probable that while these momentous changes were in process an equally important modification had begun. This change affected the blood. It caused the blood cells to become smaller and at the same time better conveyers of oxygen. These cells also began to lose their nuclei. As a result, certain animals passed from a cold-blooded, scaly reptilian condition to that of the warm-blooded, hair-covered mammal. The constant warm temperature of the blood in these mammalian forerunners must have been a decisive influence favouring the further development of the brain.

In many respects the reptilian brain is inferior to that of the mammals. All of its sense departments are fairly well represented. The senses of smell and taste have made slight advances over the amphibian stage. Body and contact senses have perhaps gained some slight advantage over the previous period. In sight and hearing there were some improvements. Collectively the reptilian mechanisms for managing impressions obtained through the senses are considerably better than those of such animals as the amphibious frog. At least one of the reptiles (*Sphenodon*) developed a third eye in the middle of the forehead. This is not, however, a highly efficient visual organ. The sense combiner in the reptile also shows some advantage, although in the main the reptilians appear to have acquired little more of practical value, except greater speed and more power, than their predecessors, the amphibians.

Even when reptile development took that bent which led to the appearance of birds, the brain received but a slight benefit from this adjustment to the air. Selective progress in the bird's brain is unquestionably found in that marked expansion involving the department of sight. Body sense also expanded to meet the requirements of sensing and balancing the body in flight. But to offset these advances both the sense of smell and the sense of taste have undergone considerable recession. Adaptive progress here, as in many other instances, emphasized one department with some apparent loss of advantage in other parts. Consequently the sense combiner, which ultimately produces the most effective combinations of sense impressions, has shown no conspicuous advantage among the birds.

Disappearance of the Great Reptiles

The reptile stage of life, especially in its most imposing phases, witnessed but little advance in the progressive development of the brain. During this period all of the great departments of brain structure, such as the endbrain, the interbrain, the midbrain, and the hindbrain, were retained and somewhat expanded. But that highly important mechanism that was finally to act as the superbrain, technically known as the neopallium (new outer coating of the brain, the cortex), had not yet been acquired. It may be in part for this reason that, as the Mesozoic period advanced, catastrophe was rapidly overtaking many of the great reptilian groups. Of the eighteen orders of reptiles that once filled the world, all but five were mysteriously swept into oblivion. Why they passed is not yet clear. It may have been due to great changes in the surface and climate of the earth at different times. It may have been that the gigantic size of these reptiles made the struggle for existence too severe or the food supply too precarious. Whatever the cause, they all seem to have paid the penalty of excessive specialization. The five orders which have survived these destructive catastrophes include the snakes, the crocodiles, the lizards, the turtles, and the lizard-like tuateras of New Zealand.

Notwithstanding this wholesale destruction, there was a priceless heritage handed down from the Age of Reptiles. This heirloom was the beginning of the warm-blooded mammal, which slowly developed from the humble pro-mammalian reptiles. It endowed the animals that were to rule the next great period of the earth's history with power to get about on four feet, with increased ability to withstand great changes of climate, with added capacities in preparing their food for digestion. This last advantage depended upon a new kind of teeth which the mammals inherited from their immediate reptilian ancestors. All of the teeth possessed by primitive reptiles were fang-like (laniary), used for seizing their prey or tearing their food. These reptiles had no grinding teeth, and this condition left the responsibility of digestion to the stomach and other organs. In most of the mammals digestion begins in the mouth with actual mastication. The early pro-mammalian reptiles (*Cynodonts*) were equipped with grinding teeth, and their dental apparatus, as in all mammals, included incisors, canines, pre-molars, and molars.

Teeth such as these were important items in the legacy received by the mammals from their ancestors, the pro-mammalian reptiles.

When the Warm-blooded Mammal Appeared

In the fourth or mammalian stage, life entered upon the Age of Mammals with all of these new endowments. Almost at once it began to show signs of progress. It was in the brain that this progress became most apparent. A new mechanism long in the making now came into existence. This new structure may be rightly called the superbrain (neopallium), since it soon proved to be the most decisive step yet taken in the development of the sense combiner and in the further expansion of all the senses. At first it did not make its appearance in any preëminent manner. It came as an outer covering over the ancient parts of the endbrain. Within it, however, were possibilities of expansion such as were possessed by no other part of the brain. Ultimately it added about twelve billion cells to be used in many different kinds of brain activity. This addition was especially characterized by the orderly arrangement of the cells, layer upon layer, almost as if each successive layer imparted some new capacity for the management of life. In its fully developed form this structure constitutes the cortex of the hemispheres, and with its fibre connections makes up as much as eighty per cent. of the entire brain.

It could hardly be expected, even after the first arrival of the mammals, that this new brain addition would at once attain its fullest development. In fact, the first attempts along this line were feeble. A new and great production of weird mammals was in process. It might almost seem as if the imposing shadows of the previous Age of Reptiles still hung over these early mammalian experiments. Huge, ungainly proportions were still the fashion. In many instances the primitive mammals themselves developed gigantic and awkward bodies. They were strange, unsightly beasts as we know them now from their fossilized skeletons and from reconstructions of them. Were it possible to reassemble them, what a sensation they would create in our modern world. Even the best efforts of our foremost showmen would be ineffective to describe those strange monsters of most unfamiliar appearance, with their peculiar armours, their long unsightly horns and tusks, their strange hoofs and claws. The mammoth, the mastodon, the amblypod, the titanothere, the creodont, the sabre-toothed tiger, and many others would be among them to excite wonder.

The Paths to Extinction and Progress

But all of these have passed, in part at least, because, like the dinosaurs, they possessed inferior or unprogressive brains. Indeed, many of the earliest mammals had brains that in some particulars resembled those of the reptiles. They grew in size and power until they became repulsive brutes, although their brains improved but little. In many of them the superbrain developed only in a small way. It was notable not for its size but for the position it occupied above more ancient structures. In their struggle for life these huge beasts seemed to be unable to adjust themselves to changing environment; so probably when the conditions became too severe, not having the capacity to adapt themselves, they failed to survive. Many orders of these animals became extinct in the early part of the Age of Mammals (Oligocene and Eocene, thirty million to sixty-five million years ago). Others, showing more progressive tendencies, continued to advance, and their descendants have come down into modern times. One striking difference between these progressive and unprogressive mammals was certainly in the brain. Wherever this organ remained primitive, wherever the superbrain was only feebly developed, the fate of extinction seems to have been a foregone conclusion. Such animals soon reached the end of their line. But wherever the superbrain expanded, there the signs of progress were unmistakable. One extremely important factor in the survival of most of the mammals alive to-day was the progressive development in the most recently acquired portion of the brain. Great practical results were brought about by its expansion in the administration of brain power. It produced, so to speak, the final consolidation of all the sense departments under one roof. Reactions connected with the sense of smell and of taste, which had so long depended upon the primitive endbrain, marked this structure as the most advantageous location for centralization. Whatever may have been the influences that established this preference, here the departments of body and contact senses, of sight and hearing, were finally organized. The effects of this consolidation were immediately felt by the endbrain. It at once became a superbrain in the truest sense. Rapid expansions in the actual size of the hemispheres were the first signs of this new development. Then came the process of convolution and folding to obtain more brain room, and this for the same reason was followed by still more complex convoluting. These advantages especially favoured contact sense, the expansion of which was largely due to the fact that the mammal body was now covered with a highly sensitive skin equipped with hair. Such a skin was a new sensory device by which finer impressions of touch might be conveyed to the brain. In this manner the animal was able to form more complete judgments concerning objects with which it came in contact. Little by little, these judgments of touch became more critical and discriminating. A great range of understanding of the world through touch sense was made available. One critical impression of touch was added to another until complex judgments in this sense were constructed. Similar expansions in the powers of vision, hearing, and body sense led to their localization in this new part of the brain. Their most effective activity soon required still further extension, which ultimately, by the development of the frontal lobe, made provision for the highest faculties. The mammals have thus shown their progressive tendency in the acquisition of an efficient sense combiner. Through their better sense capacities they have been able to understand their surroundings more thoroughly than lower animals. Consequently their energy turnover in the brain has resulted in a better output by means of which they have made more ample adjustments to life. All of this they have been able to accomplish because they possessed a mechanism of incalculable value, the superbrain. Yet the mammals have not in all cases utilized this mechanism to its full extent. Its advantages have been applied in different ways and for different purposes. In some instances they have been utilized for the special adjustments of the hoofed animals, or in the hunting craft of the great meat-eaters, or in that furtiveness of the moles, which seek their protection by burrowing in the ground. The advantages of the superbrain were applied to many other diverse specializations, such as the adjustments of bats for flying, or of beavers, seals, whales, and porpoises for living in the water.

The Superior Brain of Mammals

The mammalian brain has made possible a wide range of behaviour and adjustment. This range exceeds that of the fish, amphibian, reptile, or bird. Concerning the increased capacity of the mammals as a class there seems to be no doubt. But this greater power of adaptability is also true of every mammal. The differences in this respect between the lower mammals, like the rat, the opossum, or the sloth, when compared with the bird, the snake, the frog, or even the fish, may not be striking. But when we contrast the actions and capabilities of such mammals as dogs, horses, elephants, or any of the cat family with those of the bird or snake the vast differences speak for themselves. A dog, for example, has by comparison with lower vertebrates a greatly increased capacity for getting on in life. He is capable of adapting himself to many complications incident to his associations with man. He has a much more ample repertoire of performances. He is capable of learning many intricate accomplishments. In general, such learning is also true of most of the higher mammals; it is particularly true of those having a highly developed superbrain. Even aquatic mammals like the seals show a remarkable degree of adaptability. They are among the most interesting of trained performers. A casual glance is sufficient to reveal what an excellent superbrain they possess. Elephants, in spite of their huge proportions and awkwardness, are capable of remarkable adjustments. Their brains are also highly developed.

Yet, however decisive the mammalian superiority in brain power may be over the lower vertebrates, most of the mammals are held down by many handicaps, restrictions, and limitations. They all possess a capacity for broad adjustments to strictly limited conditions. For life in the water, in the air, upon the plains, underground, or in the forest, they may be well adapted. But the specializations of their own bodies hold them to their specifically restricted adjustments. With trunk and head, with hoof and paw, with wing and flipper, they may do the things which these implements make possible. Here their opportunities cease. In this way even the progressive mammals are confronted by serious obstacles. These mammalian obstacles were difficult to overcome. Some of the mammals, however, became specialized for a more varied kind of life. They manifested a strong tendency to live chiefly in the trees. This fact influenced their further adjustments profoundly. It opened the way for new specializations in their limbs. It gave a new direction to progress, which finally called upon the brain for its supreme development. These important tree-living animals are the monkey kind and the manlike apes. All of the events in adjustment preceding this great epoch might be likened diagrammatically to a succession of plateaus. Each plateau, beginning with that of the fish, then rising to the level of the amphibians, of the reptiles, and finally of the mammals, contributed some important elements to progress. From these at length came the upper level of the apes, that plateau destined to give rise to many varieties of primates, and also to afford those footholds essential to the further upward climb of man.

CHAPTER III

MAN IN THE MAKING

HUMAN PROGRESS FROM PREHISTORIC TO MODERN TIMES

Arrival of Man

LONG before man appeared upon the scene the brain had passed through certain preliminary grades. Its basic patterns had been perfected. Its most important mechanisms had been improved. All manner of animals inhabited the earth in those preparatory days—fishes, amphibians, reptiles, birds, and mammals of many varieties. They were the stepping stones of progress. When at length the first members of our family arrived their brains were barely human, and they themselves were crude human beings. There was a certain triumph in their advent, however, for at last there were men. The Age of Man which they inaugurated was to differ from all preceding ages in the products of human achievement. This great inaugural event, however, made no particular stir in nature. Its beginnings were insignificant and humble, just as the brain of these earliest men was a far less imposing organ than that possessed by modern people. It was still a crude brain, unrefined in many of its structural details and small in its capacity. Hundreds of thousands of years were still necessary for such a brain to attain its highest efficiency.

To most of us who are accustomed to count time as the hours between breakfast and dinner, or, at the most, as the proverbial threescore years and ten, these long periods sound fabulous and fantastic. In contemplating the past our vision usually stops short at the beginning of history, about five or six thousand years ago. Such a focus is unfortunately nearsighted. It leaves us insensitive to the much longer prehistoric period. Through all this unrecorded time man struggled upward to achieve those successes which at length established the Age of the Frontal Lobe.

Much evidence of this great prehistoric period is now available. Examined carefully and without prejudice it reveals what man must have been when his human journey first started. It tells us much of how he lived and acted; also by what means he succeeded in lifting himself up step by step from his lowly beginnings.

The Duration of Human Existence

It is natural that our first inquiry should be concerning the length of time during which the human race has inhabited the earth. The exact figures, as might be expected, are a matter of much dispute and difference of opinion. All authorities, however, agree that the several stages of human progress must have required a remarkably long period. None of the modern estimations of this period is less than five hundred thousand years. Many calculations, such as those of Sir Arthur Keith, far exceed this figure and place the origin of man as far back as a million years or more. The beginnings of the human species are usually attributed to the early part of the Pleistocene, or the late part of the Pliocene. Keith, however, believes this does not permit of sufficient time for that development which produced all of the effects evidenced in the known features of modern man, as well as those of certain extinct varieties that have long since passed from the human stage. Concluding his famous work, the *Antiquity of Man*, Keith expresses the opinion that "There is not a single fact known to me which makes the existence of the human form in the Miocene period an impossibility." This view would set the origin of man back to an astonishingly remote period in the neighbourhood of twelve or fifteen million years ago.

Professor Osborn has recently revised his original estimations concerning the beginning of the human race. He now attributes the rise of man to a time one and a half million years ago.

In all his races, both living and extinct, man constitutes the sixth family in the primate suborder, *Anthropoidea* (manlike). This family is known as the *Hominidæ* (men of all types). The progenitors of the human family split off from a common primate stock at some time early in the Oligocene. At this critical juncture, probably twenty-five million years ago, two great branches of the suborder parted company. Thenceforth they developed independently of each other. The first branch from this common stem gave rise to human races. From the second branch arose the great modern anthropoid apes, including the orang-outang, the chimpanzee, and the gorilla. The vast difference that exists between man and all other living creatures is evident in the complexity of human affairs. In size and form of body there are many notable resemblances between man and the apes, particularly the great apes. But here the similarity ends abruptly. Man has created a new world, which he strives to control both by laws of his own making and by subjugating more or less completely all other creatures to his will. His races to-day throughout the world are collectively known as the species *Homo sapiens* (man of wisdom). This species comprises the African, the Australian, the Mongolian, and the European varieties of mankind.

Four Extinct Races of Men

Study of human fossils and ancient implements has revealed the former existence of at least four prehistoric races of man. These races took their parts in the human drama and then, in consequence of factors not altogether clear, became extinct. It is not surprising that man's obscure prehistoric beginnings are all but lost in the great geological ages which lie behind his recorded history. There can be small wonder that such insignificant traces of his remains have yet been brought to light. The search for these remains has been in progress for little more than a century. Doubtless when this exploration becomes more extensive, also when more people are engaged in its organization, a considerable collection of relics revealing man's primitive stages will be discovered. Nothing more than a meagre record could be expected because so little effort was originally made to preserve the remains of the earliest prehistoric men. In those long-distant days the bodies of the dead were either disposed of by burning, or merely cast out to be devoured by beasts and birds of prey.

The principal criteria for estimating the antiquity of human remains are four in number. First, the age in geological time of the strata within which the remains are found. Second, the fossil remains of the animals associated with the fossil remains of man, whether these be of still living forms, or entirely extinct species. Third, the human artifacts, that is, implements, ornaments, and other objects produced by human hands, found with the remains. Fourth, the structural characteristics as to skull and other parts of the skeleton, which distinguish these fossil men from living races.

Quite as important as the fossilized bodily remains of prehistoric man are those ancient works of human hands that have been slowly collected as a result of untiring search and scientific industry. It is now possible to classify this great body of evidence. Besides revealing the actual presence on earth of prehistoric man, this classification clearly demonstrates the occurrence of certain cultural stages prior to the historic period. The extinct races of men already brought to light appear to vary considerably from the modern man; so much so, in fact, that a question has been raised concerning the wisdom of creating for each of them a new genus within the human family. One reason for this distinction is that no one of the extinct races may properly be called the ancestor of living man. Some arrangement in the chronological order of man's appearance on earth is desirable. The exact period of each extinct race cannot be given. But within certain broad limits we are able to assign each prehistoric man to his proper time and place.

Javan Ape Man

Probably the oldest, most primitive of extinct races is the ape man of Java (*Pithecanthropus erectus*). This ape man belonged to what is called the Trinil race, which, according to Keith, originated more than one million years ago. The ape man, although definitely human in type, had many simian qualities. He was also so similar to man as to justify the view that he represents some transitional stage in human evolution. He possessed a head and a face not unlike those of an ape, but his brain was nearly twice the size of the brain of any simian including the largest of the great apes, the gorilla. It was this transcendent advantage that lifted him above all of the anthropoids and assured him an unassailable place as a member of the human family.

The fossil remains of the ape man were discovered in 1891 by a Dutch army surgeon. Dr. Eugen Du Bois made the discovery on the Bengawan River in central Java where he had been excavating in the hope of finding pre-human fossils. He actually did find a number of mammalian bones, including a single upper molar tooth, which he regarded as those of a new species of ape. On carefully clearing away the rock and gravel at this site on the bank of the river, the top of a skull came to view about a yard from the spot where the tooth had been found. Further excavation brought to light a second molar tooth and a left thigh bone. Both of these were about fifteen yards from the place where the skull had been discovered. These scattered parts were carefully studied by Du Bois, who, in 1894, published a description of a new animal—*Pithecanthropus erectus* (*Pithecus*, ape; *Anthropus*, man). The entire term was meant to signify an upright standing ape man. The word "*erectus*" refers to the thigh bone concerning which Du Bois observes:

> We must therefore conclude that the femur [thigh bone] of *pithecanthropus* was designed for the same mechanical functions as that of man; the two articulations [upper and lower joint surfaces] and the mechanical axis correspond so exactly to the same parts in man that the law of perfect harmony between form and function of a bone will necessitate the conclusion that this fossil creature had the same upright posture as man, and likewise walked on two legs. . . . From this it necessarily follows that the creature had the free use of the upper extremities—now superfluous for walking—and that these last [the arms and hands] were no doubt already far advanced in the line of differentiation, which developed them in mankind into tools and organs of touch. . . . From a study of the femur and the skull, it follows with certainty that this fossil cannot be classified as a simian . . . and as with the skull so with the femur the differences that separate *pithecanthropus* from man are less than those distinguishing it from the highest anthropoid [great ape]. . . . Although far advanced in the course of differentiation this Pleistocene [Age of Man] form had not yet attained to the human type. *Pithecanthropus erectus* is the transition form between man and the anthropoids which the laws of evolution teach us must have existed; he is the ancestor of man.

More extended study of the brain of this ancient fossil creature shows that he was in reality human. This man did, however, retain so much that was ape-like in his make-up that it is difficult to agree with Du Bois in his view that *pithecanthropus* was a direct human ancestor. He was, of course, able to walk upon both feet much like his modern successors. It also seems probable that in stature this primitive man was not greatly inferior to the human races of the present. It is likely that he employed his hands in the use of weapons and certain crude implements. It also seems probable that he depended upon very primitive means for protecting himself against the numerous enemies that beset his path and lay in wait about his camping places. His time doubtless was fully taken up by the arduous task of gaining sustenance for himself. So busy was he in these obligatory pursuits that he had little opportunity for developing industries or cultural activities. This human creature with his ape-like appearance was closely related to many beast-like contemporaries in the animal kingdom. He managed to hold his position among them only by a narrow margin of superiority. His ascendancy was derived from a dawning ingenuity, which enabled him to equalize the struggle by the cunning of his hand. He took advantage of primitive shrewdness and contrivance to outwit his natural antagonists that far excelled him in power and speed.

However manlike *pithecanthropus* may have been in respect to the posture of his body and the general character of his locomotion, it is certain that he was much below any of the known races of man in his brain power. His face and head each bore a closer resemblance to the ape than to man. His brain indicates that he had probably acquired some mode of speech, primitive no doubt, yet sufficient for the purposes of simple human communication. It is likewise probable that he lived in tribes and, being gregarious, had learned some of the advantages accruing from community life. He may have had some crude notion at least of the division of labour and its compensations in sharing the results.

Dawn Man of England

From certain flints, which seem to have many features indicating their use as instruments, Professor Osborn believes that there were primitive men living in England at a time earlier even than that assigned to the ape man of Java. These prehistoric people are called "Subcrag Dawn men." It is his opinion that they made use of certain flint instruments called "rostro-carinates." Dr. Osborn, believing that these primitive people are close to the beginning of the human race, places their origin in the Pliocene, 1,300,000 years ago. In consequence of the discovery of certain somewhat different flint instruments, he is of the opinion also that the Subcrag men were followed at a little later period by the Foxhall Dawn men (antiquity about 1,200,000 years). Disputes about these early prehistoric Englishmen arise from the fact that no actual human remains of them have yet been found. This, fortunately, is not the case with the now famous English Dawn man of Piltdown, attributed by Professor Osborn and other authorities to the last part of the Pliocene (a little over a million years ago). Piltdown is a town in the weald of Sussex not many miles from the English Channel, between two branches of the Ouse River. To the east of it is the plateau of Kent upon which have been found many flints of earliest prehistoric times. It was at Piltdown that the most famous of English Dawn men was discovered by Mr. Charles Dawson. The fossilized remnants consisted of a number of fragments of this extinct man's skull. Because of the fragmentary condition of this fossil, it was necessary to give each piece its proper relation to the head in order to reconstruct the skull. A reconstruction of the Piltdown skull was first presented to the Geological Society of London, in December, 1912, by Sir A. Smith-Woodward of the British Museum, and its discoverer, Mr. Charles Dawson. The announcement of this remarkable discovery deeply stirred the interest of scientific circles. An unknown phase of the early human existence was about to be revealed. The reconstructed skull as pieced together impressed all who saw it as a strange blend of ape and man. It seemed that the missing link for which the early followers of Darwin had ardently searched was at length forthcoming. But whether this was the long sought-for missing link or not, the Piltdown strata in Sussex told of a race of human beings who inhabited England long before history had made its feeblest beginnings. Dr. Smith-Woodward believed that the Piltdown fossil dated back to the early part of the Pleistocene period, but Sir Arthur Keith and Professor Osborn now advocate an antiquity far more remote going back to some portion of the Pliocene. Although it is impossible to be more exact in these estimations of prehistoric time, it is clear that a very primitive race of men lived in England long before Cæsar's invasions; in fact, ages before the ancient Britons claimed the land that was to produce many of the most brilliant lights of history. By some the Piltdown man is regarded as the direct ancestor of modern races; by others he is held to be an independent branch of the human family of quite unknown affiliations.

Neanderthal Man

Some time early in the Pleistocene, variously estimated from 800,000 to 900,000 years ago, another race of man made its appearance in Europe. This was the Heidelberg race (*Homo Heidelbergensis*). These people manifested many traits distinctly more human than the ape man. It is believed from the implements found in the neighbourhood of his fossil remains that the Heidelberg man made use of crude implements both of wood and stone. This man, although he became extinct before human progress had made great advances, appears to have been the ancestor of the Neanderthal race (*Homo Neanderthalensis*). This latter is the third race of prehistoric men recognized up to the present time. Much more than all others who had gone before him, Neanderthal man has left traces of himself. Many of these relics are the stone implements that he employed. From these implements it is evident that the organization of his life had made long strides in the direction of his more modern successors. His advances in industry and in cultural development laid the foundation for all the stages that progressively evolved as the human race rose through the Old Stone Age. Yet the fate of Neanderthal man was not unlike that of other prehistoric men. In time he also became extinct. His disappearance occurred about fifty thousand years ago, when a fourth and even greater race of primitive men came into Europe. These were the Cromagnons. After they had completely replaced the Neanderthals they flourished for a long time, in the end to be replaced by the races of Neolithic men which continued dominant up to the time when man gained mastery over the metals.

It seems clear, then, that the earliest human beings began as simple, nomadic hunters. After the passage of great intervals of time and an actual succession of races, men acquired the crude essentials of manufacture and then gradually, as in the Cromagnon period, developed the dexterity and æsthetic sense of the artist. Finally, in the New Stone Age, they learned the practices of agriculture.

The past of prehistoric man has been subdivided into periods characterized by the presence of implements employed in his several activities. In general, these periods bear the name of French stations or towns near which the discoveries of the implements have been made. French archæologists have so successfully devoted themselves to the efforts of classifying the flint implements that they have established a chronological order in the development of human progress during the long periods of man's prehistoric existence.

The Old Stone Age

Man's first great epoch on earth was the Old Stone Age (Paleolithic, 900,000 years ago). In this era, which began at some time in the first interglacial period, the only implements were devised from flint or stones of other kind, from wood, carved ivory, and bone. The Old Stone Age was followed by the Neolithic (New Stone Age), which began in postglacial times and rapidly led up to the thresholds of history, through the Bronze and Iron ages.

Long before the Old Stone Age it is probable that man was at work in the slow development of industries that later were to assume great importance. Hunting was the great incentive out of which all of his early industries were evolved. Little is known of his cultural development, although it seems fairly clear that the Subcrag Dawn men used certain implements called rostro-carinates, while the Dawn men of Foxhall and Piltdown employed very primitive implements known as eoliths. These were so crude in appearance that they are looked upon by many as merely accidental forms. With such simple and limited instruments, man's struggle for existence in these earliest days must have been most severe. Even at the time when the Old Stone Age began, the primitive flint implements manifested considerable development. For example, in the Pre-Chellean cultural stage (beginning 700,000 years ago), the chase is represented almost exclusively by a simple flint knife. This knife, although extremely crude, in conjunction with other equally crude combinations of stone and stick, gave man a slight balance of power over other animals inhabiting the field and forest as his competitors. His simple equipment furnished the means to gain his daily food, and to establish that footing by which he rose step by step.

War in this period was not among man's highly organized pastimes. He appears to have had no implements for warlike pursuits. He had, however, invented certain instruments for industrial and domestic purposes, such as a flint scraper, a planing tool, a drill, and a stone hammer. Nothing among his primitive equipments appears to have answered the purposes of art or artistic production.

In this early Pre-Chellean period, man was a vagrant hunter. He lived without the protection of habitation and was thus exposed to the devastations of the great meat-eating animals that followed his wanderings. He had not acquired sufficient constructive ingenuity to protect himself against these dreaded marauders. They stalked him in his marches by day and lay in wait on the outer edges of his camps to find him an easy prey when he slept at night. The less fortunate members of his tribes were within easy reach of these night prowlers that waited only for darkness to help them in the capture of their human quarry. Man's slow imagination required ages to show him that he held in his own hands the power to subjugate the beasts of prey. For a long time he struggled on this low level of intelligence. He lived a hand-to-mouth existence, passing his days like other animals, getting his food supply as he dared, and protecting himself as best he could. Doubtless some critical occurrence like the discovery of fire and its uses may have furnished a new incentive for his advance. Some great change in climate with increasing cold may have stimulated him to more vigorous exertion, may have forced him to become a more persistent hunter of animals, both for their meat and the warmth to be had from their protecting skins. Long winter seasons when game was scarce may also have taught the wisdom of storing his supply of provisions and thus aroused in his imagination some conception of the advantages in thought for the future. Living along with him was an imposing host of other mammals. Among them were the lion, the wolf, the cave bear, the deer, and the wild boar. Over the plains roamed the Etruscan rhinoceros, the Mosbach horse, and the ancient elephant. Following this game he wandered from station to station, always living near the course of the great rivers, but showing little tendency to establish a permanent abode. A restless migrant, he was moved by the dictates of the seasons almost as instinctively as the migratory birds and beasts. He had not learned the secrets which later enabled him to stand against the severe vicissitudes of climate. The idea which gave him that self-assurance to stake out his own claim, to assert his right to his own angle of earth, was still in embryonic state.

Neanderthal Progress

The foundations of that possessive sense destined to become the chief characteristic of the human race and at length the ruling passion of humanity had as yet been laid down only in their simplest form. It was Neanderthal man who introduced the first real advances over this primitive level of life. In the Chellean cultural period (500,000 years ago), even more in the Acheulean period (400,000 years ago), his race developed rapidly. His progress is shown by a great increase and considerable refinement in all of the small implements which he employed.

He now developed a chisel or adze-like tool for shaping his wooden implements. He made flint points to form darts and spear heads to aid him in the chase. But for all these advances, it was not until Neanderthal man passed into his wonderful Mousterian stage of culture, about 300,000 years ago, that the human race took a most decisive step forward. This step was in every sense critical and epoch-making. It may also be looked upon as a highly profitable step. The effects of it have made themselves felt with increasing force upon all the subsequent development of the human race. It was a new departure that, taken so long ago, actually led the Neanderthal man to the threshold of an idea in many ways quite original. Ultimately the expansion of this idea was to become one of the keystones of all social organization. It may indeed be regarded as the fundamental principle in the upbuilding of human society. This notable step forward gave the Mousterian man the first real conception of property holding. It implanted in his mind that germ out of which grew the rights of possession. This was an idea which was handed down by him as an heirloom to all the remainder of his race, and to all other races of mankind. The conception of property holding developed from the fact that the Neanderthal man in Mousterian times became a cave dweller. He sought shelter from the elements in these rude dwellings fashioned by nature. Why he had not availed himself of these shelters long before is not difficult to understand. The caves which he might have found to his liking were already inhabited by dangerous tenants, such as the cave lion, the leopard, the hyena, the wolf, the great cave bear, and perhaps even the dread Machærodus or sabre-toothed tiger. All of these were his natural enemies. For the most part they had been successful enemies. Man had scarcely dared to dispute the right of way with them, far less the right of possession. Through all his long periods of upward progress, he had not yet learned the means by which he could contend with these beasts of prey on anything like an equal footing. They took from him at will and his retaliation at best was feeble. They, rather than he, were the real masters of the situation. This state of affairs was bound to continue until some critical discovery revealed a new instrument whose deadliness placed in human hands a supremacy over these creatures. Some strategy, some modification of the old flint instruments, perhaps some new combination of them with fire, at length gave Neanderthal man the needed advantage and then he drove the hostile beasts out of the caves. In time he established there his own dwelling places, and there proclaimed his inalienable right of possession. Such a hazardous undertaking undoubtedly required a hardy courage and an unwavering persistency. Yet a hard-fought contest of this kind could not fail to have a marked influence on the final outcome. Once man had gained the right of ownership, all of the struggles incident to it served to emphasize his final sense of possession. This triumph did much to stimulate human desire for gain. It seems fairly clear that from it arose the incentives of conquest. Since Mousterian times man has expended much of his energy in exploiting this new advantage. He has made laws to justify and regulate it. The rights of possession have had a dominating influence over all of his economic and political organizations. Most of his moral code has been built up around these rights. States and empires have been founded upon them, while the governing principle in the life of the individual has been the right to have and to hold. In a word, this newly expanded sense of possession started by Neanderthal man has become an essential element in all the achievements of mankind. It has no less been the cause of much woe and maladjustment in the race.

Mousterian Success and Character

It is difficult to estimate the importance of this contribution to the development of human progress. We may at least give Mousterian man due credit for establishing this new assertiveness. He likewise deserves recognition because this achievement was an outstanding milestone on the road toward higher humanity. For this reason it is worthy of a special commemorative date. As chronicled by Professor Osborn, this memorable occurrence, the beginning of cave dwelling, took place about 300,000 years ago. In more senses than one it was a red-letter day for humanity. It was especially a red-letter day because of the recurring bloodshed of innumerable wars destined to arise out of the lust and greed inspired by this expanded sense of possession. This, however, is the most unfavourable aspect of the Mousterian's new idea. He himself should not be made to appear too black on this score. He was actually a considerable personage and introduced many other new ways of looking at life that have been highly advantageous to us all.

Living in dark caves as he did, especially in the long bleak winters, as the glacial periods crept down upon him, he must have found much of mystery in those dim recesses to stimulate his imagination. It is probable that he became a believer in occult forces of nature, and perhaps even developed a system of magic. These suppositions become more probable from the fact that he, for the first time in human experience, established the custom of burying the dead. The men who lived before him belonged to what may be called the pre-burial period. This fact unquestionably accounts in part for the scanty human remains before Mousterian times. The Neanderthal Mousterian not only buried his dead but he developed an elaborate burial ceremony. The general nature of this ceremony is shown by the position of the body and of the limbs as they were found folded and flexed in the fossilized remains of these men of the Old Stone Age. With certain primitive people this is still the custom. Even in the case of some of the ancient Egyptian kings many personal belongings were buried with the dead. Favourite weapons of the chase, useful implements of one kind or another, ornaments and other trinkets presumably dear to the departed ones, have been found with the skeletons in these Neanderthal sepulchres. Special attention was given to prevent pressure upon or crushing of the head by means of placing large flat stones upon either side of it. There are some indications that even as far back as the Old Stone Age man, as part of his burial service, deposited certain articles of food beside the body of the departed. All of these facts clearly reveal that as long ago as 300,000 years man had acquired his first religious ideas. There is every suggestion about these burial ceremonies that the Mousterian cave man believed in another life after death. He appears to have had a strong conviction that the body was but a temporary container of some intangible spirit that in its time passed on into another world. It seems probable that he also believed in the return of the departed spirit to its earthly habitations, else why did he place food in the sepulchres? In his crude way of thinking he seems to have had certain well-fixed ideas of the pursuits and occupations in the life hereafter. For this reason he left a useful collection of weapons and other implements close at hand, ready for the spirit that had left the body. The Mousterian idea of immortality may have been simple, but there is no doubt that it existed. Whether there was a belief in God or not is difficult to discern. It is probable, however, that the Mousterian, like all other primitive people, did have some conception of a supreme being, and that he had thus laid the foundations of religion.

It is for these reasons that the cave-dwelling Mousterian man especially deserves our attention. The features of his face and the character of his body as reconstructed by scientists make him appear to be a particularly formidable human being. Everything about him indicates that he was powerful and aggressive. In a word, he was a splendid fighting machine with heavy, protruding lower jaw, low beetling brow, thick and short neck, long and heavy-muscled arms, short, powerful legs slightly bent at the knees. He was a fierce and dangerous antagonist; one, from all we know of his history, as courageous as he was powerful. It is probable that in consequence of his cave dwelling he had begun to live in fairly large organized communities. Such life as this had many influences upon his social activities. It developed his use of language. It stimulated his interest in industries other than those of the chase. It caused expansion in his imagination, leading to the establishment of racial tradition. It produced the spirit of individual competition as well as the pursuits of tribal rivalry. War up to this time seems to have been limited very largely to individual encounters. Now for the first time differences of opinion and controversies between one community and another were most likely settled by group combat. Here, therefore, were laid the foundations of war that was to prove one of the most irresistible and costly of all human indulgences. The self-assertiveness, which must have resulted from the cave man's realization that he had finally gained the upper hand in many details over the natural world, caused him to change his attitude. Instead of being a fugitive, he now became a conqueror. It was this positive self-feeling that gave rise to most of his more expansive ideas. The multiplication of these ideas easily led him on into the realm of fancy and brought him many illusory interpretations concerning the workings of nature.

During the Mousterian period Neanderthal man did not make many material changes in the implements used before his time. In some instances there was a distinct improvement of the old ideas; in others there was a distinct decline or even suppression of some of the most effective instruments. The cave man's aims, however, were considerably modified by his new mode of life. His sheltered existence lessened his physical powers to resist disease. The making of clothing from the skins of animals also grew out of this more sheltered type of life. In the end it produced a people less accustomed to the elements than those earlier and hardier races that had lived in the open. The effects of this need for clothing made themselves felt not only in the industry of producing garments but quite as much in the production of implements necessary for such work. Cave dwelling permitted disease and imperfect hygiene to go their full length in producing inroads upon this great Mousterian race. The ravages of infection and contagion had better opportunity to exert their baneful influences. These and other insidious factors were secretly at work. In course of time the Mousterian culture began to show signs of a steady deterioration. For some mysterious reason these men of the Old Stone Age slowly began to lose ground. The prominence held by the Neanderthal race during lower Palæolithic times was distinctly on the wane as this period approached its end.

Cromagnon Ascendancy

Finally a profound change came over the inhabitants of western Europe. For some as yet unknown reason the Neanderthal race entirely disappeared from the earth. Its place, however, was taken by another and a greater people, the Cromagnons. Without question this was a replacement of a lower race by one of much higher development. The Neanderthal was on a distinctly lower plane than any now existing human type. The Cromagnon ranks high among the races of mankind in intellectual attainment and in known capacities for production. He belongs to the species *Homo sapiens*, that same species of man which has made modern history. He held sway during the last part of the Old Stone Age, appearing in Europe about fifty thousand years ago. Like those races which had gone before him, he passed through many interesting phases of culture and growth. All of these were characterized by the development of stone implements, thus making him still a man of the Old Stone Age. He added many new attainments as a result of new human capacities. He stands out particularly as the first artist of mankind, and sets a mark as one of the most splendid examples of humanity both for his superb physical appearance and for his remarkable mental qualities. But he, too, like all others who preceded him, was destined to decline and then to disappear.

The Cromagnon is interesting to us because he was the probable conqueror of the great Neanderthal race. What secret power he had to achieve this conquest, to subdue and destroy these fierce cave dwellers, is still unknown. It may have been that he brought with him some new implements for warfare, such as the bow and arrow, and that he had many other advantages of this kind. In any event, he showed no quarter to the Neanderthals, whom he seems to have destroyed completely. He did not even follow the custom of many conquerors, of intermarrying with the women of the conquered race. No generally admitted sign of Neanderthal features or characters persists among the race of men after the last Mousterian days. Beyond question it was the increased brain power of the Cromagnons which gave them their real advantages. This opinion is based on the appearance of the large brain case of this race and the development of the almost modern forehead and forebrain. In the main, our admiration for the ancient Cromagnon people depends upon something entirely different from their powers of conquest. They may have been great as warriors, but they were far greater as artists. This is the aspect of their lives that interests and influences us most.

The Cromagnons were a race that developed somewhere in Asia and migrated westward into Europe. They came in contact with the Neanderthals and probably destroyed them. They had no ancestral connections of any kind with this other race. They possessed a brain capable of more complex ideas, greater comprehension, more reasoning powers, a wider, more facile imagination. Still more they were endowed with a highly artistic sense and were capable of advanced education. Their society was differentiated along the line of capacity and talent for work. Their artistic productions as shown in the mural decorations of their caves were so excellent as to place them among the truly great achievements of mankind. In the pursuits of industry and domestic life, the Cromagnons added little in the way of innovation. They adapted and perfected what the Mousterians had previously used. They did introduce, however, what no other people had ever employed; namely, tools and implements for sculpture and engraving. These tools in the main were small and delicate instruments made of flint. Among these was a fine drill, an engraver, an etcher, a carving chisel, a mortar, a hammer stone, and a polisher.

Cromagnon Cultural Periods

The Cromagnon, like the Neanderthal, passed through certain cultural phases. Each of these periods lasted many thousands of years and each of them was much longer than the Christian Era. The first of these cultural steps was the Aurignacian period, in which the great awakening of artistic enthusiasm occurred. The peak of artistic devotion, however, came in the Solutrean period, which was the acme of achievement in the flint industry. Decline set in during the next, the Magdalenian period, which brought the closing stage of Cromagnon culture. And then in the Azilian period the last survivors of the greatest race in the Old Stone Age, grown old in their industries and feeble in their art, saw the setting of the Cromagnon sun and the passing of their kind into the darkness. Many changes came about in Cromagnon industries, due to the influences of trade invasions and new inventions, but in their art these people showed one continuous and sustained development.

The impressive feature about Cromagnon art, especially in the Aurignacian period, is the absence of that period of infantilism and crudity almost always observed in the artistic development of primitive races. The Cromagnon first reveals his artistic effort in a state of sturdy youth. His art passed directly into a relatively mature stage. Its treasures preserved in the art galleries of the ancient caves, comprising remarkable drawings, sculptures, and paintings, fully warrant the title of "Palæolithic Greeks" conferred upon the Cromagnon. Indeed, they resemble the Greek and Egyptian artists in many ways. Like them, the Cromagnon resorted to painting his reliefs whether they were of the bison, the horse, the deer, or the great mammoths. The relative simplicity of his technical skill depended upon the employment of fewest possible lines and boldest of strokes. To his accuracy of reproduction and his simplicity of style he imparted a third great quality. This added artistic element, which has made his art live in a class well up to the standards of later periods, was a feeling of motion, particularly of locomotion. With this he vividly endowed the animals carved upon the walls of his cavern, upon bone or ivory.

Motives of Cromagnon Art

It is clear that the Cromagnons were cave dwellers like the Neanderthals, but they also depended largely upon the chase for their living. Why, then, did they in the dark recesses of their caverns resort to these remarkable artistic activities? These efforts could scarcely be meaningless diversions. They must have been more than pastimes, for hours not devoted to the hunt or combat. Such arduous pursuits as these surely had some serious and pertinent object in their lives. Many explanations have been offered for the remarkable outburst of artistic enthusiasm in Cromagnon times. The one most generally accepted is that the art of these people was a part of their hunting magic. In the history of primitive races it has repeatedly occurred that drawing and design have a special significance in the actual maintenance of life. For example, the Australians draw pictures of animals they use for food. Sitting on the ground about these pictures, they perform certain ceremonies which they believe will insure a plentiful supply of the food they need. The American Indians are in the habit of carving images of animals. They also draw the signs representing rain. In the presence of these emblems they make incantations and believe that by this means they will secure abundant harvest and complete success in their hunting expeditions. Images and pictures act as a sort of magic talisman by means of which to exercise an influence over those animals which serve for food.

But we do not need to go back into the pre-history of the Old Stone Age, or to the superstitions of people still in a primitive stage. Not so long ago the picture of a man was supposed to represent his spirit, and the possessor of such a picture could exert a magic power over his person. Only a few centuries ago learned judges condemned to death men and women on the evidence that they possessed images or pictures of people they were accused of bewitching. Until quite recently there were certain sorcerers and magicians in Sicily who for a price would destroy a hated enemy by the simple executionary method of sticking pins into a wax image of this undesirable person.

It seems to require no further explanation to understand the pictorial efforts of the Australian natives and American Indians. Like them, the Cromagnons drew for the most part the animals which they employed for food. This may not in all respects be a satisfactory answer to the question: Why did man of the Old Stone Age resort to art? It is, however, a good working theory. It shows a real motive for his efforts in this direction. To his mind, all of his works of art assured him some peculiar magical control over the animal life that was necessary for his living and well-being.

Men of the New Stone Age

The fate of the Cromagnon race was no exception to what had gone before or what would follow many times thereafter. Race after race, nation after nation, rose and became master, declined and passed into final extinction. As the day of Cromagnon ascendancy waned a new race invaded western Europe. The Old Stone Age came to its end approximately ten thousand years ago with the advent of the more vigorous Neolithic (New Stone Age) man. He developed a great innovation in manufacturing his implements, making his instruments better and more useful by polishing the stone. Neolithic man was far more practical and thoroughly utilitarian than his predecessors in the Old Stone Age. He introduced many economic advantages and substituted the benefits of applied science for the delusions of magic and sorcery. The man of the New Stone Age, unlike his

Cromagnon predecessor, did not alone pray for his crops. He tilled the soil and planted seed. Perhaps he believed in a magic ritual for his hunting expeditions, but to make his food supply as secure as possible, he domesticated many animals that he liked to eat. He was unwilling to depend solely upon hunting magic and art sorcery. He had discovered the true magic of agriculture and sought to control nature by the toil of his hands rather than by mysterious incantations and pictorial art. As a farmer and a cattle raiser he required a permanent home, and in consequence the New Stone Age gave a fresh impulse to the upbuilding of man's possessive sense. Neolithic man became a land holder, and this advance was a long, provocative step in the direction of modern humanity. Because of it man had to learn new ways and means of defending his claim and of asserting his right. Very quickly this new assertiveness led to the more sanguinary ages of Bronze and Iron with their effective equipments for offense and defense. Its influences finally reached historical times. Ultimately these more aggressive tendencies created all of the armed camps that we are pleased to call civilization, ancient, mediæval, and modern.

At the close of the New Stone Age all of the direct ancestors of modern European races were established in Europe. During the Bronze Age man rapidly learned those new capacities which enabled him to make a permanent record of himself, and thus he entered upon his real historic period. Some authorities set the beginning of this period only so far back as the beginning of the Egyptian calendar. In round numbers this is five or six thousand years ago.

The dawn of history was followed by a procession of great events which began in the early Egyptian dynasties. The development of Pharaonic art and culture, the regal splendours of Babylonia and Chaldea, the incomparable achievements of Greece and Rome, followed in rapid succession. Each of these civilizations in its turn contributed to the development of the race. Then came the long eclipse of the Dark Ages in mediæval times, and at length the brilliant light of the Renaissance, the illuminating influences of which have been carried forward in that steady progress of material accomplishments characteristic of modern times.

A brief review of man's progress in his prehistoric existence shows the following races in his advancement, known by fossil remains:

1. Ape man of Java (*Pithecanthropus erectus*). Professor Osborn prefers to consider him the Dawn man of Trinil. Probable antiquity about one million years. Probably employed crude stone implements and was a nomadic hunter. Had a poorly developed human brain; nothing known of his cultural development. Chief contributions to human progress: human frontal lobe, human speech, and a complete erect posture.
2. Dawn man of Piltdown, England (*Eoanthropus dawsoni*). Antiquity over a million years, probably employed crude instruments known as eoliths and thus belonged to the Dawn Stone Age. Had a fairly well-developed human brain. Was a migrant hunter. Nothing known concerning his cultural development. Chief contribution to human progress: further development of the brain.
3. Heidelberg man of Germany (*Paleoanthropus*). Antiquity

about 800,000 years. Fairly well-developed human brain and frontal lobe. Probably employed crude stone implements. Little known of his cultural phases. Chief contribution to human progress: first man of the Old Stone Age and probable progenitor of the Neanderthal race.

4. Neanderthal man (*Homo primogenius*). Probable antiquity 600,000 years. A well-developed human brain and frontal lobe. Made and improved many flint implements. Hunter and cave dweller. Had definite cultural periods known as the Chellean, Acheulean, and Mousterian. Chief contributions to human progress: established idea of permanent abode, became dominant over other animals of the earth, introduced human burial, laid the foundations of religion. Founder of human assertiveness and supremacy.
5. Cromagnon man (*Homo sapiens*). Probable antiquity 50,000 years. Well-developed human brain and frontal lobe of modern type. Hunter and artist, employed somewhat refined flint implements of the Old Stone Age. Had definite cultural periods known as the Aurignacian, Solutrean, Magdalenian, and Azilian. Chief contribution to human progress: the conqueror of Neanderthal man; the world's first great artist. The founder and introducer of art.
6. Neolithic man (*Homo sapiens*). Probable antiquity 10,000 years. Human brain and frontal lobe of modern type. Employed polished flint implements of a highly developed kind. Was a hunter, herdsman, and farmer. Chief contributions to human progress: introduction of agriculture, culinary art, domestication of animals; also establishment of more permanent abode.
7. Bronze and Iron Age men (*Homo sapiens*). Probable antiquity 7,000 years. Human brain and frontal lobe of modern type. Used implements made of bronze and iron. Chief contribution to human progress: introduction of the metals for human utility.

In addition to these prehistoric races of men, certain other early members of our family have been recognized in the latter part of the Pliocene and early part of the Pleistocene. These races include the Subcrag and the Foxhall Dawn men who appear to have employed the rostro-carinate flints. Still another race was the Cromerians, who made and used the giant flints found embedded in the cliffs of Cromer.

Prehistoric man is thus gradually emerging from his long obscurity. His skeletal form is known from more than 350 specimens of his fossil remains. In Java, in central Asia, in Rhodesia, central Africa, in Gibraltar, in the Island of Jersey, in France, in Germany, in England, in Austria, and in Galilee, Palestine, these remains have been found.

All phases of man's early existence are important to our modern thought and development. As the curtain of the past is lifted to reveal the long, prehistoric vista of human existence, it is possible to sense the vast distance that man has come since his journey began. It is also possible to see how he has made his way and why he has progressed. From its earliest appearance on earth the race has grown in humanity as the brain expanded. In man's first struggles brain power endowed him with a capacity to develop and to hand down certain cultural activities. The earliest instruments that he fashioned gave rise to an uninterrupted stream of human achievements which has passed on as the main current of culture and knowledge. It was this capacity for progressive and racial learning that distinguished the human brain. Estimated by his accomplishments, it seems necessary to assume the existence in man of some special power different from all other living creatures. This distinguishing endowment is variously called the soul, the psyche, the spirit of man, or human genius. Its name may be immaterial, but its source is the secret of our supremacy. If we acquired this power as the divine gift of a creative miracle, that is one thing. If we earned it through a long and tedious process of evolution, that is even a more promising and an altogether different thing.

CHAPTER IV

EDEN OR EVOLUTION

GENESIS AND THE ORIGIN OF SPECIES

Early Beliefs in Creation

ALTHOUGH we may entirely reject the evidence of man's presence on earth long before the dawn of history, even so there still remains a perplexing question that must be answered. What was man's origin? It is surprising how many people have attempted to solve this troublesome problem. It seems to be one of the first questions that primitive man tried to answer for himself when he began his earliest speculations. He was naturally anxious to know who made the land and the water and the sky and all that is in them. He was especially interested, when he thought about such things, in deciding how he came to be what he was himself. And so, from earliest times, beliefs concerning the beginning of things have sprung up all over the world. They constitute a mass of speculation, which is called cosmogony (beliefs or theories about the creation of the universe). Only a few races or tribes of mankind have failed to indulge in speculations leading to such beliefs. Appearing as they do in the infancy or early life of a race, these beliefs must be the fruit of the primitive human mind. In peoples who have failed to progress and have always remained primitive, such beliefs, like many other traits and customs, continue for generations almost unchanged. Sometimes they become an important part of the religion of the race. If they are looked upon less seriously they form themes for folklore.

This searching question about man's origin has always been present and is, in fact, still with us. In times gone by, when man was primitive, or at least more primitive than he is to-day, he tried to answer the question as best he could. He was hampered by lack of facts because his knowledge and understanding of his own surroundings were limited. His racial experience in the world had yet been too brief for him to do more than see the great generalities of nature. At best he could merely surmise the truth of the universe. He had neither the training, the methods, nor the instruments necessary to disclose the intimate details upon which reasonable theories might be based. Being so largely destitute of facts, he relied upon intuition or drew heavily upon his imagination. It is a matter of wonder that his beliefs often took such noble form.

Not infrequently a common central theme runs through the beliefs of primitive people, even though they may belong to different races and are separated from each other by long distances. Such, for example, is the belief in the manlike appearance of the Supreme Being held by the Hebrews, Greeks, Romans, and many other ancient civilizations. Early ideas concerning *creation* illustrate this common or central theme still more vividly. Doubtless the conception of creation has its supreme expression in the opening chapters of Genesis in the Hebrew Testament. But other primitive people had exactly the same ideas about creation and the origin of man. This way of solving the problem must have been one of the inherent tendencies of the human mind in its earliest beginnings. Isolated peoples in far-distant parts of the earth could not have shared such similar ideas as a result of racial contacts or propinquity. Time and distance set them widely apart. The similarity might be ascribed to traditions handed down from a common stock. In any event, an identical theme runs through the creation story of many different peoples. The most effective record of this theme is given in Genesis, especially in the first chapter, the King James version of which is accepted by many as the highest literary mark ever set by the English language. It is of particular interest for us to follow the sequence of events in this incomparable chapter which depicts creation with such grandeur that it may well be called inspired.

Early Accounts of Creation

According to this record, creation proceeded as a succession of separate miracles. First came the miracle creating heaven and earth, then the creation of light, of the firmament, of the earth set apart from the waters, of vegetation upon the earth, of the sun, moon, and stars, of fish and fowl, of beasts and cattle and all creeping things, of man and woman together in the image and likeness of the Creator. The second chapter of Genesis repeats the story of creation, but this time in a minor key, with certain striking differences and discrepancies. The grandeur of the original description and its sublime intuition are missing. The master mind which conceived it has obviously been replaced by one at once much more naïve and manifesting a thoroughly parochial interest in the affairs and frailties of humankind. This second narration largely reverses the original order given to creation. By it man is created before all other animals and woman last of all. This account produces man from the dust of the ground, into which the Creator breathes the breath of life and gives him a living soul, while the rib taken from man is used to create woman. The discrepancies in the two accounts are obvious at once. To explain them the second chapter is attributed to a very early writer (Jehovistic document). The first chapter is ascribed to a much later writing (Priestly document) made during the Hebrew captivity in Egypt.

Earlier than this Biblical record was the Babylonian idea of creation. These people also conceived that man was molded out of clay. According to the Babylonian version of creation, the god Bel cut off his own head, and the other gods, catching the flowing blood, mixed it with the dust of the earth, and from this bloody paste molded the forms of men. The Babylonians believed that men were wise because their mortal clay was thus tempered with divine blood. According to the Egyptians, the father of the gods molded men out of clay on his potter's wheel. A Greek explanation of man's origin contains the same idea, in that Prometheus is said to have molded the first men out of clay at Panopeus in Phocis. These naïve conceptions about the origin of mankind, common to the Hebrew, the Babylonian, the Egyptian, and the Greek, were doubtless handed down to these ancient civilized people by their savage or barbarous forefathers. Legends of creation of exactly this kind are current among savages and barbarians of the present day. It is particularly interesting to note the different forms in which this story has made its appearance in many distant places of the earth.

Creation Beliefs of Barbarous People

The Australian blacks, near Melbourne, held that the Creator cut large sheets of bark with his big knife. He placed on one of these a mass of clay and prepared it with his knife until it had the proper consistency. Then he set a portion of the clay on another piece of bark and fashioned it in human form, making first the legs and then the trunk and arms and finally the head. Having finished his molding, he took stringy bark from the eucalyptus tree, made hair of it, and attached it to the heads of his models. When all was finished he blew his breath into the mouths and noses and navels of these clay men until they rose and spoke as full-grown human beings.

In New Zealand the Maoris believed that a certain god took red riverside clay, kneaded it with his own blood into a likeness of himself, with eyes, legs, and arms exactly similar to his own. When this model was finished he breathed into it the breath of life through its mouth and nostrils, with the result that the clay man at once came to life and sneezed.

Among the Tahiti there is a tradition that the first man and woman were made by the chief god, who created them out of red earth. In Netherland Island, one of the Ellice Islands, a great deity is supposed to have made models of man and woman out of the earth and brought them to life by lifting them up. Similar in general conception is the tradition of creation among the Pelew Islanders who believe that certain of their deities made man and woman out of clay by kneading it with the blood of various animals. This feature is a new detail and somewhat of a departure from the general story. It shows, moreover, the interest which these primitive people had in explaining the different behaviour of their fellow men. Thus they believed that the characters of these first men as well as their descendants were due to the characteristic traits of the animal whose blood was mingled with the clay. Men, for instance, who had rats' blood in their clay were thieves. Those who had serpents' blood were sneaks and informers. Those who were vitalized by cocks' blood were brave and daring.

According to a Melanesian legend in one of the Banks Islands, the great hero Qat molded men from red clay taken from the marshy riverside. At first he made men and pigs to appear alike, but subsequently he forced the pigs to go upon all fours and caused men to walk upright. This distinction indicates man's early recognition of the subtle meanings of the erect posture. Qat also constructed a female out of flexible twigs. Finally she smiled at him, and by this unfailing sign of feminine allurement he immediately recognized her as the first woman.

Inhabitants of the Kei Islands believe that their ancestors were fashioned out of clay by the supreme god who breathed the breath of life into the clay models. The Dyaks of British Borneo claim that the first man was made by two birds. After several failures in attempting to hew him out of rock they at length molded him out of damp clay and infused into his veins the red gum of the Kumpang tree. When they called him he answered, and they gave him a name which in the Dyak tongue means "molded earth."

In India also the same kind of legend explains man's origin. The Kumis who inhabit the hill tracts in eastern India believe that a powerful god made the world and the trees and the creeping things first. After this he made a man and a woman, shaping their bodies from clay. When he had finished his work a great snake came while the god was sleeping and devoured the two images. This occurred several times, so that the deity was much perplexed. Feeling that after his day's work he needed a good night's sleep, it was impossible for him to sit up to protect his handiwork. At length he conceived the plan of making a dog out of clay before he created his next models of man and woman. This device solved the problem in a satisfactory manner. The god was now able to sleep in peace after his hard work of modelling human beings, since the dog, watching over them, would bark and frighten away the destructive serpent. To this day the Kumis believe this is the reason why dogs howl when a man is dying.

Africa has similar legends about the creation of mankind. Many of the natives on the White Nile believe that men were modelled out of clay. They even go so far as to explain the different complexions of various races by the differently coloured clay out of which they are molded. Their great creator, wandering about the world, found pure white earth or sand and from this he fashioned the white man. Returning to Egypt he molded red and brown men from the mud of the Nile. Finally, coming upon black earth far in the depths of Africa, he created black men.

The story of man's creation out of clay also occurs in America among the Eskimos and the Indians from Alaska to Paraguay. Many of the Eskimos have the belief that a certain spirit made a man of clay. Then having set him upon the shore to dry he breathed into him and gave him life. Certain Indians of California conceive of an all-powerful being who created man out of a deposit of clay which he found on the shores of a lake. From this clay he made both male and female, and the Indians of the present day are descended from this original clay man and woman.

The Mayas in Central America believe that their gods first made men out of clay, but that these clay models lacked vitality because they were dissolved by water. Then the gods created man out of the wood of one tree and the woman from the sap of another. Unfortunately these human beings could neither move nor propagate their kind, and for this reason the gods caused a shower of pitch to produce a flood, which destroyed this wooden race. A few of them survived, however, and from them are descended the small monkeys. The Maya gods at last created four perfect men out of yellow and white maize, and, wishing to confer the greatest boon, while these four perfect beings slept, four women were created for them.

Primitive Ideas Foreshadowing Evolution

It is interesting also to find that all savage people did not believe in the legend that ascribed the origin of man to clay models or to effigies made by some supreme being. Many primitive races appear to have preferred the theory of evolution to this other idea of creation. In any event, even if they did not fully recognize the nature of their belief, their idea was that man evolved from some lower form of animal life. The particular form of animal from which this evolution started varied considerably with the local colour, with the character and with the opportunities of different people.

Some California Indians believe that they are descended from coyotes. In their early stages of evolution all members of their tribe walked on all fours. Slowly they acquired some of the features of human beings, one toe or one finger at a time. Then came an eye or an ear, until at length these animals grew to be perfect human beings by losing their tails. This loss, which was regarded as deplorable, came from the habit of sitting upright.

The Iroquois, belonging to one important clan, hold that they are the descendants of mud turtles that formerly inhabited a certain large pool in their territories. The Choctaw Indians believe that they were descended from crayfish, while throughout the Osage Indians it is generally understood that their ancestors were a male snail and a female beaver. A great flood carried the snail down the Missouri River, leaving him upon a bank, where the sun ripened him into a man. In time he met and married a beaver maid, and these two were the ancestors of the Osages. The Delaware Indians call the rattlesnake their grandfather and would on no account destroy one of these serpents.

Certain Indians of Peru claim to be descended from the puma or American lion, and this animal is worshipped as their god. Some natives of East Africa look upon the hyena as one of their ancestors. The death of this animal is mourned by the whole people with great funereal ceremony. On the Gold Coast of West Africa certain tribes believe that they were descended from the horse mackerel.

Natives of Borneo think that the first man and woman were born from a tree which had become fertilized by a creeping vine that waved to and fro in the wind. Some of the primitive inhabitants in the northeastern extremity of Celebes believe that they are descended from apes and that the parent stock of these animals still inhabits the woods. The aborigines of western Australia considered that their ancestors were swans, ducks, or various other kinds of water birds, which were later transformed into men.

All of these illustrations of the creation idea among primitive people show that man has held at least two widely different views about his own origin. One of these is the idea of separate miraculous creation; the other corresponds to or foreshadows the theory of evolution. In accordance with the view of separate creation, a god or a tribal hero was the great creator who fashioned the first members of the race in their present form. According to the other view, man was evolved from lower forms of animals, or even from vegetable life. These two viewpoints of man's origin still divide the peoples of the world. It is probably true, as Sir James Frazer has said, that "by weighing one consensus against the other, with Genesis in the one scale and the Origin of Species in the other, it might be found, when the scales were finally trimmed, that the balance hung even between creation and evolution."

The development of the evolutionary theory among civilized people has a long history. This theory has already passed through many interesting phases. Doubtless other equally interesting phases lie before it. At present there are many who still believe that Darwin was the originator of the evolutionary idea. This belief is in no sense true. The origin of the doctrine long antedates Darwin's time. It may be traced back to the age when the human race first began to think clearly. Like many other things of high cultural value, it had its earliest recognizable beginnings in the Greek period—in those days when man sought to gain an intelligent understanding of himself and the world in which he lived.

Growth of the Evolutionary Theory

The basic conception of evolution is as old as Empedocles (450 B. C.). Aristotle (384–322 B. C.) was the originator of the theory of animal descent, which he formulated with remarkable clearness. A strong inhibiting influence fell upon this conception of life as a result of mediæval scholasticism. This influence restrained further developments until the subject was again reopened in the Eighteenth Century. The works of Leibnitz and Buffon (1707–1788) reawakened interest in this problem. Modern constructive efforts to formulate the theory of evolution did not begin, however, until the early Nineteenth Century. By a strange coincidence, the real founding of this theory occurred in the year of Darwin's birth, 1809. Up to this time, with few exceptions, it was thought that man's body was the result of special creation. Some savage people, as we have seen, have believed that man was derived from lower animals. But this belief was only a fantastic forerunner of the evolutionary concept. The birthplace of the theory was in Paris. It may appear strange that such a doctrine did not originate in the great schools of learning, and that it first saw the light in the quiet, out-of-the-way location of the Museum of Natural History. The names of three scientific immortals are associated with this revolutionary conception of the animal kingdom. All three of these distinguished men lived at the same time, worked together at the same place, and together profoundly influenced our modern views of man's place in nature.

The most noted of this famous trio in his own day was Cuvier (1769–1832). He was a professor of comparative anatomy and though only forty years of age was accumulating the material for his epoch-making work, *Ossements Fossiles*. This work was to show conclusively that the great ages of time, filled with multitudes of strange, extinct animals, had passed over the earth before the dawn of our modern era. Cuvier believed that each group of these extinct animals represented a series of separate creations. It was doubtless his energetic and brilliant insistence upon this point that denied to the French nation the first place of distinction in advancing the theory of evolution. Although he held vigorously to the old creative interpretation of life, Cuvier was in a sense an unconscious promoter of the evolutionary idea. His recognition of a succession of epochs in the earth's history and in the animal inhabitants of the globe was an important step toward the modern theory. Besides this, his keen powers of observation had enabled him to discern one of the chief principles underlying evolution. This principle is known as the law of "correlation of parts." In consequence of this law there is a definite relation of one part of the body to another, as well as a combination of these parts in the habits of the animal. Thus, horns belong with hoofs, and hoofs are associated with complicated grinding teeth, which latter in their turn are possessed by animals having complex stomachs and feeding on plants.

The second great pioneer in the discovery of life's true origin was somewhat younger than Cuvier. This was Geoffroy Saint-Hilaire. He was intent upon seeking the common plan upon which all animals with backbones were built. In this way he was laying the foundations of that broad conception of life which holds that all living things have a common descent.

The third of these great French contemporaries was more obscure than either of his associates in the Museum. In his own period the public heard and knew little of him. He was a retiring person, but an indefatigable student. As time passes it is he who stands as the towering figure of this famous trio. In 1809, when he was already sixty-five years of age, he made his remarkable contribution to knowledge. His careful studies of nearly fifty years were then published in two small volumes entitled *Philosophie Zoologique*. This was a milestone in human progress. In consequence of this work alone the name of Jean Baptiste Pierre Lamarck will stand as one of the most eminent figures of science. From his long and laborious researches he had reached the conclusion that all living creatures were the outgrowth of a common tree of life. In this treatise of his there appears the first clear declaration that man has been evolved from some anthropoid ancestor like the chimpanzee, and that man's erect posture has been derived from one which was ape-like.

The Lamarckian and Darwinian Theories

The Lamarckian theory of evolution holds that progress takes place by the imperceptible transformation of one species into another through the efforts of the organism to adapt itself to new conditions. It also maintains that, by inheritance, the changes thus produced are handed on from one generation to the next. These changes may be slight, almost insensible variations produced by the use or disuse of certain parts and organs. Through their accumulated effects they are capable of transforming one species into another. The following quotation from Lamarck's *Philosophie Zoologique* (Vol. 1, p. 349) furnishes some of the more important details in the concept by which he explains the evolution of man:

> Indeed, if any race of primates (quadrumanes) whatsoever, particularly the more highly evolved of them, were to lose, either from force of circumstances or any other cause, the aptitude for tree climbing and of grasping the branches with their feet, as with their hands, for security of grip, and if the individuals of this race, for a series of generations, be obliged to use their feet only in walking, and cease using their hands as feet; then there is no doubt, from the evidence produced in the foregoing chapters, that these apes would finally be transformed into man (bimanes) and that the great toe would no longer be separated from the other toes like a thumb, the feet merely serving the purposes of progression.

Despite the fact that Lamarck was a pioneer he did not, in so far as the evolution of man is concerned, induce a single anatomist of his own time or of a succeeding generation to follow in his footsteps. In this respect his great work remained strangely ineffective. The more persuasive introduction of the evolutionary theory was made by an illustrious English naturalist, Charles Darwin. After a somewhat mediocre university career, for which he received the degree of Bachelor of Arts, Darwin devoted himself to the natural sciences. In his early manhood he spent five years on the famous barque *Beagle* in which he made a trip around the globe. Twenty-three years later (1859) he published his renowned *Origin of Species*, which proved to be one of the most revolutionary books ever written. In an educational sense, Darwin was far more fortunate than Lamarck. Almost at once he obtained the ear of the public and started the theory of evolution on its strenuous course around the world. Twelve years later (1871) he published his second monumental book, *The Descent of Man*, which proved to be the most telling step in our modern knowledge of man's evolution. These two great books set forth the Darwinian theory. Like Lamarck, Darwin believed that progress from lower to higher forms of animal life took place as a result of insensible variations. These variations were due to what Darwin and one of his contemporaries, Alfred Russell Wallace, called natural selection. This factor was the prime and sufficient cause of evolution. Through its operations new species arose by the selective action of external conditions upon individual variations. Natural selection, as a law, implies the effects of those forces which separate living creatures into two groups—those which survive and those which, being ill equipped to make the struggle for existence, perish. The selective effects of external conditions on an organism or its parts operate in such a way that individual variations or peculiarities of advantage are perpetuated in the race and thus give rise to the survival of the fittest. Darwin in his *Descent of Man* makes clear his opinion of the manner in which natural selection has operated in human evolution:

As soon as some ancient member (elsewhere defined as some species of anthropoid like the chimpanzee) in the great series of the primates came to be less arboreal, owing to a change in its manner of procuring subsistence, or to a change in the surrounding conditions, its habitual manner of progression would have been modified and thus it would be rendered more strictly quadrupedal or bipedal. . . . Man alone has become a biped and we can, I think, partly see how he has come to assume his erect attitude which forms one of his most conspicuous characters. . . . As the progenitors of man became more and more erect and their hands and arms more and more modified for prehension and other purposes, with their feet and legs at the same time transformed for firm support and progression, endless other changes in structure would have become necessary. The pelvis would have to be broadened, the spine peculiarly curved, and the head fixed in an altered position, all which changes have been attained by man. It is very difficult to decide how far these modifications are the result of *natural selection* and how far of the *inherited effects* of the increased use of certain parts or of the action of one part on another. No doubt these means often coöperate.

Comparing the explanations given by Lamarck and by Darwin it is clear at once that they have much in common. Both suppose that man was evolved from a chimpanzee-like anthropoid. Both agree that the transformation had been initiated by a change from an arboreal to a terrestrial mode of existence. Both believe that the results of habit or of function acquired by one generation may be inherited by the next generation. Darwin made certain important additions to this theory. He applied the law of natural selection—the tendency of successful individuals to survive and prosper. He also recognized the effects of sexual tendencies and perceived that there was a law of correlation of parts. By this latter mechanism a number of structures were modified at the same time to suit some particular function of the body.

Since Darwin's time, although the general principle involved in the theory of evolution has been accepted by scientists everywhere, there has been much discussion concerning specific details of the evolutionary process. Simultaneously with the conviction that evolution was a fact in the animal life there arose an eager desire to discover its underlying causes. Many students of the problem have arrived at independent explanations of their own. To some the theory of Lamarck has been considered satisfactory; to others Darwin's interpretation is most convincing. Such differences of opinion as do exist among those who have seriously pursued this matter centre primarily upon the causes of evolution. For this reason a number of different theories are recognized to-day. It is probable that these theories do not represent all of the differing shades of opinion concerning this subject at present. They may be said, however, to express the high points of difference. Their chief interest lies in the fact that they indicate the degree of energy and determination devoted to the solution of this problem. Recent students of the Darwinian theory have modified and extended it in such a way as to make the law of natural selection entirely sufficient to explain evolution. Such students, with Weismann the most prominent among them, deny the inheritance of acquired characters. This view is known as the neo-Darwinian theory.

Lamarck's original conception was also modified and became the basis of the neo-Lamarckian theory. This view recognized all of Lamarck's ideas, including insensible variation, use and disuse of parts, and hereditary transmission. But it added to these causative factors certain influences of consciousness and the will, thus introducing an internal and psychological principle in the evolutionary process. In America this newer view of Lamarck's conception has been vigorously upheld by many naturalists (Cope and Hyatt) who attempted to explain evolution according to the fundamental laws of growth plus the inherited effects of use and disuse.

Explanations such as these seem to lose sight of many influences acting upon animal life from without and along certain determinate lines. These influences were highly specific in their character and embraced definite chemical and physical factors. Their effects were concentrated upon limited organic areas, such, for example, as the eye, but they spread to correlated organs like the brain, the muscles, and the bones, all of which are functionally continuous with the visual apparatus of vertebrates. Such a spread of modifying influences from a determinate focus like the eye throughout the entire body caused a widespread tendency to variation and thus afforded the opportunity for progressive development. This explanation is known as the Orthogenetic Theory (Eimer, 1897).

Still more recently the pendulum has swung away from this extremely materialistic viewpoint in what is called the Creative Theory of Evolution (Henri Bergson, 1907). According to this explanation the variations that bring about evolution from lower to higher forms of life require some good genius to preserve and collect the effects in the interest of progress. This presiding genius working from within is the original impetus of life, the *élan vitale*, or vital impetus (entelechy), which like some internal perfecting agency passes from one generation of germs to the next and through the developed organism bridges the interval between generations.

Philosophy, with its conception of an internal creative power common to all life and biology, pinning its faith to physicochemical factors, have vied with each other in bringing to light the causes of evolution. Among the latest explanations is the Energy Theory (Henry Fairfield Osborn, 1918). This interpretation holds that the life of every animal is due to the action, reaction, and interaction of four types of energy. The first type arises from chemical elements and compounds surrounding the animal (inorganic environment). The second is the energy derived from the body substance of the developing organism (protoplasm and body chromatin, the chief substance in the nucleus of body cells). The third source of energy is from the sex cells, especially those parts of them which contain the hereditary elements (hereditary chromatin). The fourth type of energy comes from the living matter surrounding the animal (life environment). Selection and adaptation are constantly at work upon the reactions of these four types of energy. Divergence in the form of different animals depends upon adaptations to special conditions of life as seen, for example, in the whales and the meat-eaters. Altogether there are twelve major environments for living, like the plain, the forest, the air, the sea, which require special adaptations. All life has tended to radiate out into such habitat zones, and the four types of energy represented by each living creature have been adjusted to a particular environment. This spreading out of life into many different zones of existence is a recognized principle in natural selection (law of adaptive radiation. Osborn).

The most recent interpretation is that offered by the Emergent Theory of Evolution (C. Lloyd Morgan, 1928). Evolution, according to this explanation, is the name given to the plan of sequence in all natural events. Orderly sequence presents from time to time something genuinely new. In the physical world emergence is exemplified by the advent of each new kind of atom, each new kind of molecule, each new form of life. Emergence is not the mere addition to or subtraction from existing properties. It is the appearance of something new and unpredictable from the combination of properties already in existence. A true emergence of this kind is produced by the combination of carbon and sulphur out of which the gaseous carbon bisulphide arises. This gas is totally different from either sulphur or carbon, its two combining ingredients. It is something genuinely new and hence an emergent. This principle affects all spheres of life in such a manner that it is possible for new characters, new structures, new activities to appear as emergents from preëxisting elements. Variations and progressive development may be thus explained as the result of orderly sequence.

In spite of the differences in opinion among scientists concerning the evolutionary process, there is an almost unanimous agreement with regard to the correctness of the general theory of evolution and the principle underlying it. To attempt a critical estimation of these several theories would be futile and far removed from our present purpose. Doubtless each one of them contains some portion of the truth. It is, however, their large number that is of striking significance, inasmuch as these theories indicate a widespread, profound, and growing interest concerning evolution among intelligent people. Whatever their minor differences, such theories demonstrate a determined effort in the search for truth and manifest tendencies in thinking which cannot fail eventually to reshape the intellectual outlook of mankind.

CHAPTER V

BIRTHPLACE AND EARLY BEGINNINGS OF MAN

INFLUENCES OF FOREST AND PLAIN ON BRAIN DEVELOPMENT

The place of man's origin is a matter of little significance if he came into being by a creative miracle. Any one of a hundred natal sites, chosen for reasons of local pride or racial prestige, might have served the purpose. Eden undoubtedly was most colourful, but otherwise it had no exceptional advantages. Once created and upon his feet, man had the world before him to conquer and possess. Such was the beginning and end of his story.

If, on the other hand, the human race came through evolution from lower forms of animals, then man's homeland is of utmost significance. It must have exercised a strong influence not only upon his origin but also upon all his life and progressive development.

Africa, Europe, or Asia

Some students of this subject have regarded Africa as the most likely birthplace of man. According to this view the human form first appeared as certain Nilotic negroes. From this homeland man spread throughout the world. On the other hand, the accumulating fossil evidence of man's existence seems to be strongly in favour of western Europe as a centre of human dispersal. Professor Osborn points out that between the years 1823 and 1925 there were discovered in this part of the world alone no less than 116 individuals belonging to the Old Stone Age or to the Dawn Stone Age. Two of these were members of the Piltdown race. Fossils of forty other individuals belong to the Neanderthal race. Seventy-four are accredited to the Cromagnon and other races that lived in late Stone Age times. Remains of 236 individuals belonging to races that lived between the end of the Old Stone Age and the beginning of the New Stone Age were also found. These fossil men, in all 352 individuals, have been discovered within the last hundred years. During the same period, a little more than a century, only one human fossil has been found in the entire continent of Asia, one in the Holy Land, and two in Africa. Such a great preponderance in numbers clearly favours Europe as the home of primitive man. Africa, Asia, and those parts of Oceania formerly connected with the Asiatic continent, have borne no such abundant evidence of man's early presence. Both the northern and southern continents of the New World have revealed nothing as yet that may be accepted as representing man in his early prehistoric period. This survey of the globe seems to limit the first appearance of man to European regions. In this connection it should be borne in mind that the various countries of Europe have been carefully explored in the search for early human fossils, while in other parts of the world the search is little more than just begun.

Northern Asia has also been regarded as likely to contain the site of man's birthplace. This has been the view of certain French authorities who consider the Eskimos as the most ancient northerly race of mankind. From this homeland there was a progressive southward migration of primitive tribes under the influence of the severe conditions imposed by northern glaciation. More recently attention is being directed to central Asia as the birthplace of man. This locality was suggested long ago by the great American scientist, Joseph Leidy, and this viewpoint has been supported by Professor Osborn. Dr. Matthews in considering the matter of climate and evolution discussed the origin and migratory history of man. He believes that Asia was the centre of dispersal for human migrations, which were among the last of great migratory movements of animals in the history of the world. It is his opinion that most scientists to-day would place this centre in or about the Great Plateau of central Asia. In this region, now barren and very sparsely inhabited, are probably the remains of civilizations more ancient than any yet recorded. Immediately around this region and lying upon its borders are the territories of the earliest civilizations known to man. Chaldea, Asia Minor, and Egypt lie to the west, India to the south, China to the east. From this central region came successive migrations, which overflowed into Europe during prehistoric, classical, and mediæval times. The history of India shows that similar invasions poured down upon it from the north. Toward the east, invasions in successive waves entered the Chinese Empire and North America by way of Alaska, spreading southward over the two continents of the New World.

The Top of the World

Since his recent visit to Mongolia, Professor Osborn is strengthened in his conviction that central Asia will prove the homeland not only of man but of all the greater forms of mammal life. Here, he believes, in the Gobi Desert, were the ideal surroundings for the early development of Dawn men who were the direct ancestors of the human race. His belief in this part of the world as the birthplace of man depends upon certain characters in the terrain which are essential to racial development, concerning which he reasons as follows: Man's earliest existence was mainly in the open either along river bottoms and river drifts or on uplands and plateaus. Such a life developed the finest physical qualities of the race. The earliest man could not have been a forest-living animal. Such parts of the human race as lived in forested lands have either been exceedingly slow in their development or have gone backward. Thus, the South American Indians, living in the forests, are much behind those who live in the open. Of the latter, those who live in the uplands are further advanced than those who lived in the river drifts. An alert, progressive race cannot develop in a forest, and it would be impossible for such country to serve as the centre of human radiation. Higher types of men do not develop in a lowland river bottom country, because food is plentiful and vegetation luxurious. It is upon the plateaus and the high uplands that life is most exacting and calls for exertions which are most beneficial for development. Mongolia was probably a region forested only in part, certainly not a country of dense forests. It was a most favourable upland country throughout the entire Age of Mammals. Here the conditions of life were apparently ideal, and since all other indications point to Asia as the place of man's origin, Professor Osborn looks to Mongolia and Tibet, which he calls the top of the world, as the most favourable centre offered by nature for the birthplace of man. Here he has hopes of finding our remote human ancestors. He is, however, guarded in this view, which he feels must be treated merely as an opinion. It is not yet a theory, but is, however, an opinion sufficiently sound to warrant further extensive investigation. In consequence, several great Asiatic expeditions have been sent out by the American Museum of Natural History into the Gobi Desert. Under the leadership of Dr. Roy Chapman Andrews this exploration was undertaken in the search for fossil men. One of the explorers, Dr. Nels C. Nelson, soon made the remarkable discovery that in the wide expanse of this ancient desert there had lived, ages ago, certain people whom he called "dune dwellers of the Gobi." His discovery included a great collection of flint implements of the Mousterian type, closely resembling those found in the cavern of Le Moustier in France, and thus belonging to the Old Stone Age. These newly discovered implements reveal the existence of man at a much earlier period in the

Gobi Desert than the Mousterian period in Europe. Indications of an earlier Stone industry were also found in Mongolia. Some of these ancient implements show that long ago there were probably men living in this part of the world who belonged to the Dawn Stone Age.

The latest evidence in favour of Asia as the home of primitive man was supplied by a surprising fossil discovery made by Turville-Petre (August, 1925). This new find consists of a skull of Neanderthal type, discovered in Palestine and known as the "Galilee skull." The rapidly accumulating discoveries of the past three years sustain Professor Osborn's view that central Asia is the homeland of the human race. He concludes that "while the anthropoid apes were luxuriating in the forest and lowlands of Asia and Europe, the Dawn men were rising in the invigorating atmosphere of the relatively dry plateaus of central Asia."

Home Surroundings Necessary to Human Evolution

If, as a result of evolution, man took origin from lower animals, these must of necessity have been mammals nearly like himself. They must have borne and nursed their young as he did. Mammals other than the primates differ so much from man that they could scarcely stand in the direct line of his origin. How different from him are all of the great races of hoofed animals, including the great varieties of cattle, horses, deer, camels, giraffes, and elephants. All of these are highly specialized and seem at once to exclude themselves even as remote relatives of man. So it is also with the pawed animals, the great families of dogs, cats, rats, and hares. These are definitely quadrupeds, clearly designed to meet the issues of life upon four legs. They fail to disclose anything resembling a near approach to man, either in form of body or mental capacity. The winged animals like the bats, strange specializations of the mammal kind, bear little resemblance to the human form and offer a poor beginning from which such a form might start. The swimming mammals, like seals, whales, and porpoises, also exclude themselves from direct connection with the line of man's ancestry. In fact, all mammals must be put to one side in considering this question, except a single remarkable group. The apes and their kind alone bear an undeniable semblance to men both in body and in behaviour. Many of their parts are similar to the human, such as their hands and feet, fingers and toes all equipped with nails, as well as their thumbs which may be held against each finger in turn. The apes have acquired a more or less erect posture. Some of them, called manlike apes (anthropoids), possess so many characteristics in common with man that they alone of all animals might be regarded as connected with the direct line of origin. If this relationship be true, then the nature and location of man's original homeland is of profound significance. Wherever this place may be, it should bring into combination two distinctly different types of home surroundings. It should provide this combination in order that the apes might supply the last long step by means of which man has ascended into humanity. These two different but essential types of abode are:

1. Home surroundings favourable for ape life.
2. Home surroundings favourable to human life.

A third condition must bring these two elements into final combination. These specialized surroundings must be relatively near together, so that transition from one to the other may readily take place. Does Mongolia and particularly the Gobi Desert fulfil all of these three conditions?

According to Professor Osborn's theory, the uplands and plateaus are the most favourable places for human development. Such being the case, we must also agree, then, that the forests are equally essential to the life of apes. Only a few of these animals have adjusted themselves to life outside of wooded country. Living in the trees, therefore, is the existence that favours the life of the subhuman primates (lemurs, monkeys, and apes). The forest provides the home surroundings favourable for ape life, just as the plains afford those conditions favourable to human life. Does such proximity of these two essentials exist in the region of the Gobi Desert? Mongolia is not a densely wooded country. It is a territory forested only in parts. In this light it does not seem to be an ideal locality for the final transition from ape to man. To explain this defect, Professor Osborn at present holds that man in evolving had but a brief and very distant phase of tree life. He believes that the quadrumanous arboreal stage was extremely remote in geologic time. It was never a profound or exclusive mode of life. There are those, on the other hand, who firmly maintain that in this ape to man transition a long intermediate period of tree living was necessary in order to bring about those changes in the primate stock which laid the foundations for human existence. This life in the trees was essential to determine the erect posture of man, to free his hands ultimately for purposes other than locomotion; in fact, to free them so that they might become the chief incentives in the further development of the human brain. Even from this viewpoint, Mongolia may still be considered the homeland of mankind. The forested lands throughout its extent and upon its borders might well serve as adequate surroundings for the development of life during that critical intermediate phase when the first ancestors of men had parted company with the apes and had at length become humans.

With many animals there has been a strong tendency to take refuge in the trees. The chief object of this tendency was to make life more secure either by escaping danger or by obtaining food. But with the coming of the ape kind this arboreal habit took a somewhat new turn. It furnished the early members of the monkey kind a permanent abode. Such a change to a more or less fixed dwelling in the trees produced marked modifications in the animals themselves. It created a new type of home and developed a new kind of thoroughfare over highways in the tree tops. In order to acquire a proper equipment for such transportation, both fore and hind paws became grasping organs. In consequence these animals developed four hands. They gradually gave up the older pattern of paw and claw, and by developing a new instrument connected with the arms and legs they acquired a supreme facility for grasping the branches of the trees. The tail also, in some cases, acquired similar grasping powers. Thus, as the trees became the home and the highways of these animals, their four grasping hands and their grasping tails gave them a mastery over the forest which they used to their own peculiar advantages.

The forest background of their lives played an important rôle in the molding of their behaviour. The perpetual semidarkness of their home surroundings exerted a subtle influence upon them. It might be that the forest in which they lived stood on the edge of a wide plain with a clear opening from which to look into the farther distances outside. Undoubtedly there must have been an alluring temptation in the green plains and their inviting freedom. Yet for these tree-living animals to venture into this open space was a hazardous undertaking. There were many dangers lurking in the plain and over it. Fierce creatures of every kind were there. Reptiles, mammals, and birds, all of them beasts of prey, were lying in wait for just such an adventuresome excursion. So for the time at least, and until they were better prepared to cope with the enemies outside, the semi-darkness was safer, even though the view were limited and many interesting things were left unexplored.

Effects of Tree Life

The lemurs were probably the first of these new tree-living animals. Their bodies were still slender and furry, their heads long and fox-like, their eyes widely separated, and their tails long and bushy. But in their hands and in their feet they showed the real beginning of fingers and toes. This stage marks the transition from some lower form of mammal to the primates (lemurs, monkeys, apes, and man). It was a profound change, and in it the new order of primates had its origin. The steps preceding this important one we shall consider subsequently. But with this advance there began a period of tree living which influenced all of these animals as they and their successors passed through their many stages upward. The little animal known as Tarsius, perhaps even more than the lemurs, shows the effects of these new influences caused by tree-living habits. The monkeys of South America reveal the manner in which the next step forward was taken. The effects of it appear in the shape of the head, in the almost human expression of the face, in the closer relation of the eyes to each other, and in the shape of the nose and the position of the mouth. All of these features prophesy the coming of the still more manlike apes. Above everything else, these South American monkeys are conspicuous in the history of development because of their almost human hands, and also because of their hand-like feet. Most of the members of this group acquired prehensile or grasping tails. With the appearance of the Old World monkeys, this tail began to wane in importance. It lost all of its grasping power and was reduced to much the same condition as in other animals not of the monkey tribe. Some of the Old World apes, such as the gibbons, developed the ability to stand and walk upright. In addition to this erect posture these apes had passed through another phase that brought them nearer to man. They had lost their tails. This had come about, doubtless, from their habit of sitting upright. The erect posture of the gibbons, however, was most important as a forerunner of further developments in the great manlike apes, the orang-outang, the chimpanzee, and the gorilla. These animals had grown so large that for most of them living in the trees was a matter of some inconvenience. It was necessary for them to come to the ground at times, because they found it difficult to swing from tree to tree like the smaller monkeys. Of the great manlike apes, the orang-outang still adheres rather closely to the forest. The chimpanzee, which has developed even greater cleverness in climbing, seeks the ground oftener. He has learned to walk upon all fours, using the knuckles of his hands as a support in this act. Like the orang-outang, he can stand up quite erect and walk like a man. Finally the gorilla, the largest of the manlike apes, often attains the size of nearly four hundred pounds in adult life, and standing erect may reach the height of nearly six feet. He also is able to walk upright. But the influences of tree living are so strong even with the gorilla that he has not yet made a good adjustment for life upon the ground. If it were not for the prodigious strength in his great arms it would be difficult for him to take to the trees, and he thus shows a betwixt and between specialization, not entirely suitable for the ground and too large for security among the trees.

All of the manlike apes are capable of standing and walking in the upright posture, but in this posture they are awkward and inefficient. Their awkwardness is due to the fact that the foot in all three of them retains many characters of a hand. None of them has a good foot for effective heel and toe walking on the ground. Yet in spite of the handicaps in their poor feet, in spite also of their long, ungainly arms, these apes are able to venture beyond the limits of their forest home. Some of them live in the plains or on the mountain sides. By their great strength they are equipped to cope with many of the dreaded enemies outside of the forest. The orang-outang seems to have no natural enemies because of its own great offensive power. Only two of the larger reptiles presume even to attack it—the crocodile and the python. According to the natives of Borneo, the orang always succeeds in killing the crocodile through main strength by standing upon its back and opening its jaws until he is able to tear out its throat. It is reported that if attacked by the python, the orang seizes the reptile with both hands, squeezing it with such force and biting it so ferociously that the outcome of the combat is soon decided in favour of the anthropoid. The gorilla also has conquered most of its antagonists in the animal world, and is regarded as the most powerful and the most dangerous brute enemy of man. All of these apes have acquired a certain freedom in using their hands, which are thus made available for acts of self-defense and even for a considerable degree of exploring their surroundings.

Progress in the direction of mankind had its beginning when the tree-living tendency of the apes began to recede. The recession of such tree life paved the way for those first indecisive but promising steps which took the great apes out of their ancient forest homes into the inviting plain. Finally with the complete passing of tree life there began that long and adventurous journey which was to lead over every sea and into every land, until no region of the earth remained for further conquest, until the full development of the hand and the upright posture had more and more bent the forces of nature to the designs of the races of man.

Stages in Developing the Erect Posture

The advances made toward mankind through the intermediate stepping stones of the great apes and smaller monkey kind may be traced through successive stages of tree life up to the time when the fully erect posture became an accomplished fact. These stages have been recognized as a result of exhaustive studies made by Professors Gregory and Morton. They consist of gradual changes which finally gave rise to the human foot. This structure permitted man at length to stand upright and thus gave him the free use of his hands for constructive purposes.

The first stage came in the Eocene (beginning of the Age of Mammals, about 65,000,000 years ago). At this time certain four-footed land-living animals began to live in the trees. This arboreal life had profound effects upon the fore and hind paws. In order to climb among the branches a clinging grip was necessary. Long, sharp claws developed in consequence of this requirement. The digits of the paw were short and the palms well padded. The thumb also was short but not opposable. As yet there was no squatting or half-sitting posture. The toes were likewise short and clawed. The heel was lifted off the ground. The sole was well padded and the great toe large. These four-footed animals made only an imperfect adjustment to tree life. Their movements were slow and their range of action correspondingly limited. The tree shrew is a good living example of such animals, while certain fossils of the Eocene belonging to this type have been described by Professors Matthews and Gregory.

The second stage in developing transportation came with certain light, lemur-like animals. They were still slow and cautious in getting about and depended upon a clutch-like grip. This new kind of grasping produced long digits like fingers. The toes were changed in the same manner, so that the feet began to look more like hands. (Living examples of this stage, *Loris* and *Lemur potto*.)

The third stage was a more decisive advance since transportation through the trees now combined the advantages of climbing and leaping. Locomotion was swifter and more effective. A tendency to a partially erect posture developed, and squatting or sitting up was tentatively established. All of the fingers became much longer. Most of them had finger nails, so that these animals at last possessed what might be called a hand. Changes of the same type took place in the toes. The thumb and the great toe became more powerful and both were opposable. They could be brought in contact with each of the other fingers or toes in turn. In these animals the hands were now well formed and the feet looked much like hands. It is for these reasons that such animals are called quadrumanous (four-handed). (Representative animals of this stage, *Lepidolemur* and *Notharctus*.)

The fourth stage was but a short step from leaping and climbing to swinging from branch to branch or running along the branches. This swinging by the hands is called brachiation. It had far-reaching influences upon all subsequent stages. Such swinging naturally lengthened and strengthened the arms. It produced a better grasping grip around the branches and caused the fingers to grow longer. The thumb did not participate in this increase of size. It actually was reduced in strength and prominence. This is true in most of the New World monkeys. In some of these, like the spider monkey, the thumb has disappeared altogether. It should be remembered that most of these animals had a prehensile tail which they used much like a fifth hand. The foot also developed a grasping grip and looked if anything even more like a hand than before. All of the South American monkeys, besides their ability to swing from the limbs of trees, can run along on the top of the branches in what is known as "pronograde" locomotion. But their swinging propensity probably had the greatest influence upon the final developments of transportation. It tended to bring the body in a close approach to the upright position. Many of the Old World monkeys sat in a semi-erect sitting posture, and from their habit of squatting developed thick pads (ischial callosities) over their buttocks. The leg became lengthened but was yet too much flexed at the hip to permit of the most complete erect posture. This stage is represented both by the New World and Old World monkeys, with the exception of the baboons. These latter animals are an interesting variation. They more or less deserted the old custom of living in the trees. Their bodies and heads assumed many dog-like characters, and they returned to a four-footed ground-living type of locomotion. In consequence their limbs became shortened, as was also true of their fingers and toes. All of these important changes took place in the early part of the Oligocene (second period in the Age of Mammals, probably 30,000,000 years ago).

The fifth stage occurred much later in this period when another decisive advance was introduced. For one thing, the tail entirely disappeared. The legs became more extended at the hip. Swinging from branch to branch was the chief means of getting about. This produced extremely long arms and hands, and because this swinging mode of transportation was predominant it kept the trunk more and more in the upright position. Such straightening up of the body introduced the most positive influence toward standing erect up to this time. The legs did not grow in proportion to the arms, and the feet retained a close resemblance to hands. On the ground such animals as these could make their way with considerable speed, standing upright and running much as man runs. The only difference between this kind of gait and that of the human was due to the great length of the arms and the poor feet.

This stage in the development of the upright posture is often seen in motion pictures of those animals which portray this particular phase of locomotive advance. These are the remarkable apes known as gibbons. Those familiar with them in the zoölogical gardens, or in moving pictures, will remember the peculiar way in which they run upright, holding their long arms stretched out much like balancing poles. Thus erect, they speed about in getting their food or playing with other monkeys. Their upright gait is awkward but extremely interesting. Once, however, they get into the trees their locomotion has all the grace of a bird in flight. This gibbon stage of development was one of extreme importance, since it gave the primates preceding man their first chance to stand upon two feet and to run about in something like human fashion. It is this stage that many authorities consider indispensable in the final working out of the human erect posture and human locomotion. Many students of this question also believe that the upright posture could never have been attained unless animal life had passed through that particular phase in the development of transportation called brachiation. It seems certain that this stage itself was dependent upon a preceding and extremely long period of life in the trees.

The sixth stage developed early in the Miocene (third period of the Age of Mammals, about 15,000,000 years ago). One of its chief factors was a great increase in the body weight of the apes. This greater weight caused the animals to come nearer to the ground, as is the case of the chimpanzee and the gorilla. These animals actually spend much time upon the ground. In consequence, it was necessary for them to make certain transportation adjustments. Their locomotion in the trees was still of the brachiating type—that is, they depended largely upon their arms for swinging. The arms thus became long and powerful. When the gorilla stands erect his hands hang below his knees. The legs are relatively short, but the feet in consequence of living so much on the ground look less like hands than in the lower apes. They have well-recognized broad heels, but flat soles without much of an arch. The lesser toes are human in appearance. They are much shortened and have little resemblance to the fingers of a hand. The great toe is shorter and only in a slight degree opposable. This is especially so in the mountain gorilla, in which the great toe bears a striking likeness to the same part in man. The flexion of the leg at the hip is somewhat decreased and as a result the gorilla is able to stand upright in almost human fashion. All of these changes appear, to a less degree, in the chimpanzee also. Both gorilla and chimpanzee are able to stand erect, to walk, and even run in this posture. Their gait, however, is awkward. They are greatly hampered in their locomotion by the extreme length of their arms. Usually in getting about on the ground they run upon all fours, using their arms somewhat like crutches and coming down at each step on the knuckles of the flexed hand. When aroused or charging to the attack, the adult male gorilla usually stands upright and beats its fists upon its chest, at the same time emitting a terrifying growl. When it is necessary for the animal to make speed in flight or for other purpose, it usually comes down upon all fours. Arboreal locomotion in all of the three great apes still retains much of the brachiating type. It thus requires the retention of the hands as part of the locomotor apparatus. Tree life in the chimpanzee and the gorilla, combined with partial use of the ground, did much to develop the essentials of the erect posture. It did not, however, free the hands to that extent which permitted their exclusive use for purposes more constructive than transportation. However strong the inclination toward life upon the ground may have been in the manlike apes, they were committed long ago by their predecessors to a life in the trees. This commitment still kept them true to their kind and to their simian inheritance. If they were to be more than apes, it was necessary for them to shed the stigma that tree life stamped upon them. This the modern apes were never able to accomplish.

The Parting of the Ways

At length, however, in spite of many obstacles, the tendency toward the erect posture found a new opening. It was the foot that led the way to this great opportunity. It provided an efficient supporting structure with a well-developed heel, a non-opposable great toe, and a sole containing an effective longitudinal arch. Man could at last stand upright and be secure upon a capable pair of feet. At some period late in the Miocene two branches from the stock of those animals, which had managed to get into something approaching the upright posture, parted company. This was a critical juncture. Thenceforth one branch proceeded one way and the other followed an entirely different course. The apes accepted the trees as their lot. Man, because of his two human feet and what they supported above them, acquired the earth and all it contains. Thus with tree life a thing of the past, with a true ground-gripping foot, with longer legs, with an actual erect posture, the hands were finally liberated for the purposes of human success.

The development of the human foot, which must have been in progress through vast periods of time, marks the decisive parting of the ways between the apes and the races of men. It is doubtless true that the specialization of the hand has been a potent influence affecting the expansion of the brain and of brain power. The hand itself, however, was ultimately dependent for its free and unhampered use upon the development of the foot. This great factor was the forerunner of all those elements in structural organization which finally brought about the erect posture, which set the head upon the shoulders so that the eyes might look forward and upward, and at length made it possible for the eyes to guide the actions of the hands.

Step by step, the brain has kept pace with these progressive alterations. Old and new parts of it alike bear the imprint of adaptive change. The combinations determined by life in the trees and by the development of four hands have been worked out through graded stages, from the humblest of the monkey kind up to man. Beginning with the lowly tarsius and lemurs, this advance may be traced through intermediate phases to its ultimate goal in the human brain. Mongolia, as many authorities agree, may have been the land that saw man's earliest beginnings. Whatever his homeland, a long period of tree life was necessary to develop in his predecessors those specializations by which he rose to his allotted position. It is in the tree-life part of man's history that we see the dawn of the primate brain; for it was then there occurred the earliest exploits of that great order of mammals, the primates, to which all the monkeys, the great apes, and man belong.

CHAPTER VI

DAWN OF THE PRIMATE BRAIN

THE LOWEST OF THE MONKEY KIND

We are now approaching a critical period in the history of the brain. It is a period that contains many incidents of the utmost importance. Particularly noteworthy are the episodes which favoured the production of human characteristics in the animal kingdom. These characteristics showed many manlike tendencies that much later were to appear full fledged in the human race. They were from the first limited to a single, highly interesting order of mammals. And this seems especially strange because from the beginning of the Age of Mammals (65,000,000 years ago) a great variety of new animals came into existence. The fact that a single group out of all this vast number was picked out to develop human resemblances must hold the secret of some potent selective influence. Such an influence was definitely at work. Its operations were slow but steady. Little by little it changed and reshaped the structure of the body until at length there appeared a race of animals so human in their organization that they might well have been the forerunners of mankind.

It would be difficult to conceive the kind of modification in structure that could produce the form of man from a horse, from a whale, or even from a dog. But this difficulty becomes far less in the case of the animals usually referred to as the monkey kind. In many features of their structure these animals resemble men. Existing in a great variety of forms, they manifest numerous modifications in the different parts of their bodies and exhibit a wide range of behaviour in their habits. Only a superficial acquaintance with them is necessary to reveal their many progressive traits. But their progress, like all other progress, had its humble beginnings. At first the apes were very simple creatures. Their coming, however, marked the dawn of a new day in animal life. We shall be interested to follow the advances that occurred in their mental capacities as they slowly made their progressive strides forward. We shall be particularly struck by those changes which gradually led up to the development of a brain capable to control all of the complex activities of human behaviour.

Naturally we may expect to find a simple controlling organ in the lowest of the monkey kind. As we pass upward, however, into the higher families of the apes, we shall not only observe a pronounced increase in manlike tendencies but, as the great anthropoids at length become human in miniature and then almost human, we shall recognize in these animals a brain which very closely resembles that of man.

Class Distinctions in the Monkey World

In the ape world there are animals of high and low degree. Some are so humble that it is hard to decide whether they actually belong to the monkeys or not. With few exceptions they all prefer to live in the jungles and tropical forests. We could not fail to be impressed by the striking resemblance that many of them bear to man. Yet there are such marked differences among them that they cannot all be regarded as members of the same family. If we grouped them as we do human races, we might most advantageously assign them to certain large classes according to their nearness to man.

Monkeys of lowest degree include the lemurs, the tarsiers, and all of the New World monkeys.

The intermediate monkeys in the next higher grade are those which live in the Old World, with the exception of the three great manlike apes.

The higher anthropoids occupy the top rank and are the nearest to man both in their appearance and in their habits.

These three ranks in apedom did not appear at the same time. One rank, so to speak, successively developed from another. By a process of selection and adjustment the higher forms arose from the lower. The ranking great apes owe their superiority to many traits and characters which they inherited from more humble forerunners and which they improved by the process of progressive development. The lowest monkeys likewise had their day of upward progress, during which they emerged from some mammal still lower in the animal scale. These forerunners of the earliest primates, the lemurs and tarsiers, had in all probability been gradually specializing during the latter part of the Age of Reptiles. Their ancestors came from that stock of mammal-like reptiles which started from lowly beginnings and remained modestly in the background during the reptilian period.

The Lemurs

In the endeavour to get some conception of these distant predecessors of the monkeys and apes, it is believed that the tree shrews possess those simple characters necessary for the proper starting point. The shrew is an insect-eater and lives in the trees. It has many specializations in its legs, in its head, and in its trunk. These special adjustments might serve as the beginning of those important changes in the body which later distinguished the monkey kind. In the first place, the small size of the tree shrew was particularly favourable for this purpose. Then, in the second place, its habit of living in the trees foreshadowed advantages of great promise. Such an epoch-making adjustment made its appearance when paws were replaced by hands and when definite hand-like feet appeared. If an animal like the tree shrew were the forerunner of the monkeys, it is not difficult to appreciate how the lemurs arose from this stock. They and their kind may be looked upon as the first chapter in the history of the ape world and the ape brain. At present they live exclusively in Madagascar and its small adjacent islands. They are not known in any other part of the world, although fossils of them indicate that they were widespread throughout the globe in earlier times. The reasons for their present exclusiveness and their insular homes are not clear. Geologists claim that the parts in which they live originally had land connection with the continent thus permitting their wide dissemination. The later disappearance of this connection accounts for their present isolation.

There is much in the appearance of the lemurs that distinguishes them from the monkeys and apes. Their most distinctive feature, the head, is much like that of a fox and is drawn out in a long pointed muzzle. Many characters appear in lemurs not seen in monkeys. They have no cheek pouches. Their tails, never prehensile, are usually furry. They develop no gluteal pads, which many apes possess in consequence of their squatting postures. It is in their hands that they resemble monkeys most strikingly. They have fingers and toes with finger nails and toe nails. The thumb and great toe are always well developed, but the second or third digit is often greatly modified. They also have mammary glands like the monkeys. In the female these glands assume certain definitely human characters. The lemur is a little smaller than the domestic cat. Its fur is thick and woolly. Its large and prominent eyes are more widely separated than in monkeys. The ears are long and have tufts of hair on their upper portions. The arms are not quite so long as the legs. The tail is long and often bushy. Fleshy pads appear on the palms of the hands and soles of the feet, as well as upon the palmar surface of the fingers. These enable the animal to grasp the branch of a tree with great tenacity.

Little is known of the lemur's habits in the wild state. It is not strictly nocturnal, for some of these animals are known to seek their food during the day. Often they travel about in troupes consisting of many individuals. Most of them live in the forest. Their food consists of fruits, insects, birds' eggs, and birds themselves, which latter they are most skillful in catching. During the heat of the day they sleep with the head beneath the arm and the tail curled about the neck. When walking they go upon the hands and feet, both when on the ground and in the trees. The tail is used in the manner of a balancing or steering organ. Sometimes they assume a semi-erect posture on the hind legs, or sit in a half-crouching position. Both hands and feet are employed primarily for climbing or running about on the ground.

The lemur has great ability in leaping from tree to tree. Its movements are so rapid that it can only with difficulty be followed by the eye. Hunters say that it is easier to kill a bird on the wing than a lemur when leaping. If pursued and shot at it has a habit of dropping suddenly from the topmost branches into the bushes, giving the hunter the impression that he has succeeded in killing the animal. This impression is soon dissipated upon seeing the lemur in another tree at a considerable distance from the spot where it fell. When wild the animals are said to subsist largely upon bananas. They also seem to be fond of the brains of birds. After fracturing the bird's skull with their teeth, as they might puncture a nutshell, they suck the brain out of the brain case. The lemur, however, does not eat the rest of the bird. We may see from this description that this is an animal of great agility. Not only does it possess much speed in its locomotion, but it also manifests the utmost nicety in balancing and remarkable precision in all movements.

Tarsius

Another of these lowest monkeys is a strange little animal called tarsius, which has acquired a notable reputation. Several learned authorities have singled it out as the standard bearer of human origin from some lower mammal. The tarsius is about as large as a small squirrel. Its appearance is peculiar because of its closely set bulging eyes, its long tufted tail, its protruding ears, and the small circular pads on the end of each finger and toe. Tarsiers have two curious habits that attract attention at once. They can leap with astonishing swiftness from tree to tree, often in pursuit of insects, and when they turn their heads they seem at one instant to be looking forward and the next directly backward. Their eyes, though very large and prominent, do not seem to give them the best of eyesight. The animals can see well at night, but during the day they appear to be almost stupid because in the sunlight their vision is imperfect. Tarsius lives in the jungle, usually in the low countries of the Malay Islands. During the day it passes most of its time clinging in a vertical position to the trunks of the smaller trees and underbrush. The way in which it supports itself is interesting and peculiar.

With its fingers and toes it firmly grasps its slender support, at the same time pressing inward with its long tail, which acts like a spring against the tree. If its tail is pulled away from this support the tarsier at once tends to slip backward. The tail, which has no grasping power, is used like a rudder for balancing and steering when the animal is in motion.

In some respects tarsiers are quite human. They go about in pairs and are not gregarious like most of the monkeys. Furthermore, they give birth to but a single offspring at a time. After the breeding season the female and her young find a home by themselves. There are no indications that these animals build nests or even live in holes of trees. The tarsier often falls asleep in its characteristic clinging position, and the head then sinks downward much as that of an old man asleep in his chair. Often the young tarsius will perch upon the mother's head while she is asleep, and in this position fall asleep itself. The general behaviour of the animal is extremely stereotyped and limited. It learns but little under training. In captivity it is able to make but few new adjustments. During the day its enormous bulging eyes give it an almost ridiculous appearance as it gropes awkwardly for food. This no doubt is due to the fact that its eyes are constructed for hunting at night and do not contain the specialization essential to the sharpest kind of vision. On the ground tarsius leaps like a frog but is very awkward. In the trees, however, it is extremely agile, and is probably the quickest jumper of all mammals. While grasping a small branch it can turn its head so as to look directly backward and jump more quickly than the human eye can follow. It seems to be looking in one direction and jumping in another. This is due to the great rapidity with which it turns its head. In captivity it is pugnacious and cannot be tamed. It performs its toilet much as a cat does and thus keeps itself scrupulously clean. It is not known to make vocal sounds indicating fear or anger. On rare occasions, and particularly when young, it has been heard to squeak. The infant tarsius clings to the hair of the mother's chest like other young monkeys. The eyes are open at birth, and many reactions appear at once that are long delayed in such animals as the rat, cat, dog, and higher apes.

The Marmosets

Another lowly monkey is the marmoset. It has less renown than tarsius but is nevertheless an interesting animal. It is often carried around in the pocket of its owner and fits conveniently inside of the old-fashioned fur muff. The marmosets belong to the group of the New World monkeys. They inhabit South America and Central America. Their chief interest arises from the fact that they represent one of those moments of faltering experienced by the monkeys in their upward strivings. These little animals have an almost pathetic expression and features that are in many ways quite human. Yet in spite of this human-like appearance they indicate an actual backsliding in the attempts at progress. This backsliding is most apparent in their fingers and toes. In fact, the entire hand and foot have lost most of their human resemblance. The finger nails are now replaced by sharp, talon-like claws, and the toes are equipped in the same way. The marmosets, both because of their diminutive size and the imperfections in their hands and feet, are now looked upon as monkeys that show signs of retrogression.

The marmoset is as large as a small squirrel and covered with a thick, silky fur. It is naturally very timid but soon becomes friendly to those with whom it is familiar in captivity. The female produces two or three young at a birth and in this respect is unlike most of the monkeys. The marmoset's facial appearance and shape of head are certainly more ape-like than the lemur's. The eyes are set much closer together, and are separated by a flat, narrow nose suggesting that vision now depends on the simultaneous operation of both eyes. The animal has a long, bushy tail. It lives in the tree tops or small underbrush and climbs the trees in a manner similar to the squirrel. Although it has a cat-like agility, it does not make the long and daring leaps characteristic both of lemur and tarsius. It often loses its grip on the branches and falls from a considerable height to the ground. In captivity it shows little inclination to develop new actions. It is not easily trained, and to teach it to do tricks of any kind is most difficult. It lives upon worms, insects, and fruit. It is known also to invade birds' nests and suck the eggs. Very rarely does it prey upon bird life and then only when it is able to overpower one of the smaller birds or unprotected young.

South American Howling Monkeys

In this group of lower monkeys we encounter one with a highly interesting personality, known as the "red howling monkey of South America." He is a real monkey, noisy and disagreeable, often attaining the size of a fox-terrier. He always seems to be in an unpleasant mood, showing his teeth and howling on the slightest provocation. In spite of all this ill temper, he belongs to the progressive party of the monkeys. There is not the slightest doubt that he has made definite advances along the lines of progress. If we should question this progress we would soon have our doubts set at rest when we saw the astonishing manner in which he uses his tail like a fifth hand. Even more convincing in this respect is the almost human appearance of his hands. Not long ago a young woman visiting the ape house in the zoölogical gardens was struck by these human similarities. She was still more impressed when a large howling monkey thrust his long tail through the bars and deftly tossed her hat into the air.

The howling monkeys enjoy this gift of a capable, grasping tail in common with most of their fellows who live in South America. The prehensile tail is especially well developed in the spider monkeys and in the woolly monkeys. At its end this tail looks like a long, tapering finger. It is a highly developed sense organ and gives the monkey a new instrument for locomotion and for exploring. These monkeys are able to swing themselves from the branches by their tails and thus leave the hands and feet free for other purposes.

In addition to this highly efficient tail, the howlers have developed a larynx and vocal cords with which they produce awe-inspiring sounds. Their mournful howlings are often audible for miles around, and it is supposed that they employ their cries as a means of defense to intimidate their enemies. The howling monkeys possess a slightly opposable thumb and well-developed fingers. While they are described as being the most ferocious of the South American monkeys, they are also credited with a low degree of intelligence. The face of this monkey is naked with the exception of a heavy beard that hangs beneath the chin. In captivity they are practically untamable and soon die. Their fur is usually black, but in some cases is brown or reddish brown. They live largely upon fruit, although like other South American monkeys they feed upon caterpillars and insects.

Measuring the Mentality of New World Monkeys

Professor Thorndike, of Columbia University, has made careful studies concerning the behaviour of several South American monkeys. He was chiefly interested in the manner in which monkeys differ from other animals in the mental capacities and methods of learning. In making his tests he devised certain experiments which utilized boxes with pegs, bolts, bars, and hooks. The object of these tests was to find out how the animal learned to release itself from confinement, or gain access to a goal containing food. Professor Thorndike concluded that these monkeys did not learn by reasoning. They do, however, form more and a greater variety of associations than other mammals. Their combinations of this kind are remarkably slow and ineffectual in providing any new behavioural accomplishment. Concerning the general mental development of the South American monkeys, Dr. Thorndike believes that they represent a certain advance from the generalized type of mammals toward man. This is particularly true of their sense equipment and their localized vision. All of this, he believes, is in reality an advance due to the brain acting with increased delicacy and bringing into line those activities which distinguish human mental faculty from that of all other animals. Here, at length, among the lower monkeys is well-attested proof of some progress toward the development of human capacity.

Monkey Behaviour

The way in which these lower members of the monkey kind behave deserves particular attention. It gives us the opportunity to observe certain striking resemblances to our own human behaviour. This question is one of primary importance. It acquires especial interest as we compare the brains of the monkeys and apes one with another. As the brain continues to improve from one stage to the next, we should be on the lookout for new developments in behaviour. It might perhaps be impossible to appreciate all of these minute changes among the monkey kind. It is even somewhat questionable whether such an exact comparison at the present time is necessary or possible. Yet there are certain outstanding traits of conduct that may be easily traced from stage to stage. One of the most important of these traits depends upon the development of the tail from the time when it first acted as a rudder-like organ for steering and balancing the animal until it acquired all of its great facilities as a fifth hand. After this it began to recede in importance and finally disappeared. The tail thus created a special cycle of behaviour which had important bearing upon the final outcome of man's adjustment.

Another group of reactions centre upon the manner in which the hand made its appearance, including the progressive changes in behaviour when the monkeys first became four-handed. All of these changes were dependent upon living in the trees and gradually found their culmination in an animal that could stand upon two feet and use its hands. Such usage as this foretold the beginning of human skill, of human right-handedness, and of human speech.

Very important were the changes in behaviour that made their appearance as the eyes worked more in harmony with each other. They produced a kind of vision better able to guide the movements of the hand and give more complete information concerning distance, direction, and perspective. But far exceeding all other changes for getting a better control over the surroundings were those progressive advances introduced for making the fullest combinations of sense impressions. These advances favoured the development of better powers for learning and for profiting from experience. Progress in all of these particulars concerning the behaviour of the monkeys may be clearly traced in corresponding expansions in their brains.

Brains of the Lower Monkeys

In the brains of these four very simple members of the monkey kind we may readily see the expansions that promoted development in the governing organ. It will be apparent at a glance that progress followed no direct or easy path. It met many rebuffs and obstacles. Often it faltered and even stumbled. But struggling on it finally reached solid ground and then went forward to real advances.

Placing the brains of the lemur, tarsius, marmoset, and howling monkey side by side we may see how this progress began. To guide our way in following this advance, certain signposts and milestones will prove serviceable. Three of these landmarks are deep grooves or clefts. They appear in the superbrain and indicate the places in which progress has been particularly active. Around these grooves the outer covering of the superbrain has been folded to make room for more brain cells. This folding produces convolutions with the result that the more convoluted a brain is, the more cells it has for the development of brain power. Each of these three grooves has its own special meaning as a landmark:

1. The "Sylvian groove" is a fissure that runs between the department for the sense of hearing, called the "temporal lobe," and the department for body and contact sense, called the "parietal lobe."

2. The "central groove" is a fissure between the department for body and contact senses and the department of supreme brain activity, called the "frontal lobe." This lobe of the brain is situated immediately above the eyes and behind the bone of the forehead (frontal bone). A small frontal lobe means a low brow with a correspondingly inferior mentality. As this lobe of the brain increases from ape to man, the forehead gradually becomes higher and more prominent.

3. The "ape groove" separates the occipital lobe in the back of the head from the parietal lobe. In the occipital lobe is situated the department for sight.

The three grooves form the boundary lines between the four chief departments of the superbrain, each of which is known as a lobe; namely, (1) the parietal lobe, department of body and contact senses; (2) the temporal lobe, department of hearing; (3) the occipital lobe, department of sight; and (4) the frontal lobe, department of the high mental faculties like judgment and reason.

Further advances from this point will occupy our attention in tracing the brain of the monkey kind upward. Two other landmarks in the brain have special value. One of them is the bridge (pons) which connects the larger brain (cerebral hemispheres) with the lesser brain (cerebellum). This lesser brain acts as the chief muscle timer and adjuster. It balances one muscle's action to that of another and adjusts the force of such action. All of our most exact movements, whether in walking or writing or speaking, depend upon the little brain. If it is injured or destroyed the movements of our hands and feet, head and trunk, become shaky, unsteady, and very irregular. For an animal to become highly skillful requires high development in the little brain. The animal having the highest intelligence also possesses the greatest capacity for skill in its actions. The size of the bridge reflecting the degree of this skill is a good index of the intelligence possessed by the animal.

The pyramid is another important indicator of progress. Like the bridge, it is found on the base of the brain. It is called pyramid because of its somewhat pyramidal shape. It acts as the main trunk line for getting the orders of the superbrain out to the muscles. It transmits, so to speak, the highest commands of the brain in controlling the motor machinery. By means of it we act according to the dictates of our wills. If both of these great pyramidal trunk lines are interrupted, we become completely paralyzed. The pyramids conduct the highest output of the brain's activity and increase in direct proportion as the animal's behaviour becomes more and more complex.

The brains of low monkeys are of small size: lemur, 18 grams; tarsius, 6 grams; marmoset, 6.2 grams; and howling monkey, 24.5 grams.

Size and weight of brain, we must bear in mind, vary to a considerable degree with the size of the body, so that certain other signs of expansion in the brain are more impressive. These signs clearly indicate that progress is under way as follows: First, the large superbrain begins to cover over the lesser brain. In lemur this extension backward has only just begun. It is only slightly more marked than in many of the lower animals, like the cat and the dog. In tarsius the large brain has extended backward over the lesser brain to a considerably greater degree. This is an important change because the tarsier has transferred much of its business of sight to a new department in the occipital lobe of the superbrain. The marmoset shows this transfer carried a little farther, for the large brain now overhangs the lesser brain. The great advance shown in the howling monkey reveals the way in which the superbrain has taken complete control of the situation. It now covers over the lesser brain entirely. All of this change in the superbrain has been mainly in the interest of making a better department for sight, but the departments for the sense of hearing and for body and contact senses have not been behindhand in expanding in these lower monkeys.

Another pronounced sign of progress is the gradual change in the position of the groove of Sylvius. In lemur it is almost vertical, as in the cat, in the dog. and other lower mammals. The arrangement of other smaller grooves around it is also similar to that in lower animals. In the tarsius this groove is equally primitive. It is beginning to tip backward a little in marmoset. Finally, in the howling monkey this groove has become quite oblique, as it is in most of the apes and man.

All of this change has occurred as a direct result of perfecting the organization in the department of hearing. The more tilted the Sylvian groove becomes, the better developed is the temporal lobe which carries on the business of hearing. The tilting backward of this groove also results from an increase in that part of the superbrain which lies immediately about the groove. This is the parietal lobe, the department of contact and body sense. It is in this department that the especially important information concerning the movements in the hands and feet is registered. Thus the tilting backward of the Sylvian groove plainly tells the story of improvements in the departments of hearing and of body and contact sense.

Still another sign of progress appears in the central groove, which has an equally interesting history. In the lemur this groove is just discernible as a faint dent. In position it resembles a corresponding groove in animals like the cat and dog. Lemur in this respect suggests that in its striving to part company with the lower animals, to break away from ancient contacts, and to get on an independent new line of its own, it has not been entirely successful. This central groove shows where the chief department of the superbrain begins, that is, the frontal lobe. In the lemur this department is poorly developed. In tarsius it is impossible to find anything that looks like a central groove. This animal's brain is an example of some of that hesitation which was encountered in the path of progress. The same faltering is also seen in the brain of marmoset, which has no central groove whatsoever. These little South American animals, it must be remembered, are thought to be backsliders, and this particular defect in their brain strongly supports that conclusion.

In the brain of the howling monkey we find the central groove now well developed. The superbrain shows that it is at length pursuing some definite policy of expansion in its most responsible department. Emphasis in growth is now obviously given to the frontal lobe for advancing the capacity to transact all higher mental faculties. In the howling monkey this department may not have attained any high degree of development, but its presence is undoubted, and from this relatively simple beginning it is only a matter of further expansion to bring into existence the most productive mechanism of the brain. The howling monkey shows its superiority over all lower monkeys in another respect. It has developed the ape groove, and by it the boundary between the department of sight and the department for body and contact sense is fully established.

Viewed as a whole, the brains of these four lower monkeys show distinct progress in the interests of developing a more efficient superbrain. Each of the sense departments has gradually become better defined in its boundaries, and doubtless correspondingly better organized for the administration of its duties. Rising supreme above them all there finally appeared the controlling department of the chief executive in the frontal lobe. We see this in its earliest stage in lemur. It assumes still more importance in the howling monkey. The departments of sight (occipital lobe), of hearing (temporal lobe), of body and contact sense (parietal lobe), show the effects of steady improvement from lemur up to the howling monkey. If there have been some hesitations, even some slipping back in the organization of efficiency, it is because some of these animals were rather uncertain disciples of progress. They may have been, as is probably true of tarsius, too close to the starting point where the real advances of the monkey kind began; or perhaps, like the marmosets, they ran into early difficulties along the upward climb. It seems probable that they were not able to extricate themselves with credit from these hazards or to overcome the obstacles that confronted them. For this reason their brain shows some actual backwardness. With these exceptions, however, the evidence of progress is undisputed. It seems sufficient to convince the most sceptical. The purpose of the progress is also sufficiently plain. It clearly appears to be that effort toward promoting organization in the superbrain so that the offices of the supreme executive might be established in the permanent quarters of the frontal lobe.

Measurable Improvements

Any doubts due to lack of measurable proofs may be easily overcome by several comparative measurements of the bridge and the pyramid. The size of these structures, both of which reveal the behavioural capacities of animals, has been carefully estimated. Accordingly the bridge has been assigned the following values: lemur, .055; tarsius, .057; marmoset, .095; howling monkey, .103. Thus the bridge, called by some authorities an index of intelligence, shows distinctly the advances made among these simple monkeys.

Quite as striking are the figures for the pyramid, which indicate the degree of voluntary control that the superbrain has over all actions: lemur, .110; tarsius, .032; marmoset, .064; howling monkey, .137.

From these figures the howling monkey stands in advance of his monkey associates in the index of his voluntary control. Doubtless much of this advantage is due to the high degree of hand-like specialization in this animal's hands and feet. But the grasping tail of the howling monkey should not be overlooked. If tarsius and the marmoset appear to stand lower than the lemur, it is because one of them is a primitive type of animal with a much restricted repertoire of reactions, and the other, the marmoset, is a backslider less richly endowed in the more effective motor capacities.

All of these features in the brain seem to coincide with progress in the behaviour of the lower monkeys.

They show the path which progressive advance has pursued. In the beginning, emerging from those strivings of lower mammals and with much of the mammalian heritage handed down by them, the lemurs took the first step of the monkey kind toward a new type of brain. There was prophecy in these early attempts made by the lemur. In some degree at least they foretold what this new kind of brain was to be. Obviously they had as their distant mark the ultimate upbuilding of the superbrain until an adequate department for the supreme executive of life was produced. If tarsius hesitated in reaching out toward this objective, it was none the less travelling in the right direction. The destination of this course was clearly visible in the brain of the howling monkey and other similar monkeys of the New World. In this manner the first primate steps toward a more highly efficient type of brain were taken. The conditions of tree life both incited and successfully urged them onward.

CHAPTER VII

ON THE WAY UPWARD

BRAINS OF THE OLD WORLD MONKEYS

WE HAVE seen that the first steps leading to improvements in the primate brain were taken by certain humble creatures living in distant parts of the earth, and by the great tribes of the New World monkeys inhabiting South America and Central America. These steps did not lead far along the path of progress. They were only a beginning, the first harbingers of man's arrival. Many lowly animals in the ape house at the zoölogical gardens reveal numerous features suggestive of the human being. Such features not only include their fingers, finger nails, toes and toe nails, but even more their facial appearance. Many of these monkeys look like diminutive old men. They snarl and show their teeth when angry. Their way of indicating displeasure is almost human. They make certain expressive gestures, like nodding or tilting of the head to one side in a quizzical or even pathetic manner. They make plaintive cries or sounds, in some cases almost like the notes of a bird, or they scream out loudly in anger. All of these New World monkeys are notable for one other reason. They do not make any of those humorous grimaces that are so amusing in the Old World monkeys. These latter manifest a certain drollness in their constantly changing facial expression.

The Old World monkeys include about three quarters of all living species. They are embraced in one great family, but the members of this family show many differences ranging from the huge dog-faced baboon to the small bonnet monkey. Some of them are gentle and affectionate, some are savage, pugnacious, and treacherous. This entire family is spread out over the hot or semitropical regions of the world. Many of its members live in the damp, tropical forests; others prefer rocky, almost barren country, and a few seek their homes in temperate climates. Some monkeys are found among the lower ranges of the Himalayas and may be seen in the winters playing among the branches of snow-laden trees. Two varieties seem to have a surprising endurance in really severe cold. They inhabit the elevated regions of eastern Tibet.

In picturing to ourselves the characteristics of a monkey we are apt to have the conception of an animal that can hold on and hang by its tail. None of the Old World monkeys has this kind of tail. The greatest number of them live in the trees, and the tail, while generally short and stumpy, in some cases is decorative and almost plume-like. Most of the Old World tribes are especially interesting and amusing because of a large elastic pouch in each cheek. This pouch the monkey greedily crams with food in his haste to get his meal into safe-keeping. When the cheek pouches are filled both cheeks are bulged out and give the animal somewhat the appearance of a gourmand embarrassed by a mouthful of delicacies. Later on, at his leisure, the monkey chews and swallows the food.

Baboons

By far the largest of the Old World monkeys are the baboons. They may be recognized at once by three characteristics. The head and face look much more like those of a dog than is true of other monkeys. They have long and dangerous fangs in the upper and lower jaws. They go about, like most four-legged animals, upon hands and feet which have much the appearance of paws.

Further acquaintance with the baboon shows him to be a surly, unmannerly, savage, and thoroughly undependable creature. All of his tribes have fleshy pads over the buttocks, which in some cases are large and brilliantly coloured. Some members of his clans, such as the mandrill, have faces which look like gruesome masks or hideously painted savages. The skin over the nose is a fiery red, while the cheeks are swollen, ribbed, and of a vivid blue colour. A beard of golden hue hangs beneath the chin in contrast to the dull olive drab of the body. Protruding over the lips are savage canine teeth, long and dagger-like. These baboons are about as large as a good-sized dog. The colouring of the face adds considerably to the repulsive unattractiveness of the animal. They run along on their hands and feet, with their eyes directed downward, so that they are obliged to elevate the large overhanging eyebrows in order to look upward and forward. They go about with the palms of the hand and soles of the feet laid flat upon the ground. The mother is often seen walking or scampering around with a young baboon clinging to her back. Sometimes the mother will sit up on top of a rock just like a human being. Her offspring often perches on her neck after the fashion of a well-trained acrobat.

All of these monkeys are gregarious. They travel about in large numbers. Often as many as a hundred individuals collect in one herd. Because of their aggressive disposition, they are dangerous enemies, especially when irritated or disturbed. Their long, sharply pointed, canine teeth are capable of inflicting severe wounds. Although they have no actual speech, they utter certain sounds that seem to be thoroughly understood by all members of the herd. There is quite a variety in these sounds. Some of them resemble barks, grunts, or even screams. Often they make low and subdued murmurs with various inflections, the meaning of which all the baboons seem to understand immediately. Sometimes the slightest murmur from one of the members of the herd will act as a signal or warning. This is particularly true when the baboons are out on an expedition of pillage or mischief. On such occasions they always station a lookout or outpost at some favourable point from which the signal may be given upon the approach of danger. The faintest murmur made by one of these lookouts will start the marauding baboons scampering away to safety.

Disposition of Baboons

For the most part they live in rocky places near ravines, crags, or hilly promontories where grass and trees are scanty. Their favourite abodes are usually places surrounded by wide plains. This kind of home enables them to lie in wait for the right moment to perpetrate some thieving expedition upon a garden or field and at the same time to have every opportunity of escape. They are much given to mischief of this kind. Consequently they are feared and despised by the inhabitants of the country which they infest. If attacked, they often turn upon their pursuers and inflict serious wounds upon their assailants. Some baboons prefer to live in the dense forest and climb readily about even in the tallest trees. Those that live in more open country are very agile in clambering among the rocks and are able to reach lofty heights or positions of safety. The baboon eats a little of everything, although its chief diet consists of roots, fruits, reptiles, and insects. To procure their food they are continually searching, turning over stones beneath which the desired food may be concealed. When young the baboon is often quite gentle and affectionate, but with most of them this disposition changes when they grow up. In captivity baboons are surly and unfriendly. Even those born and reared in captivity are more difficult to approach and teach than other apes. They are vindictive and treacherous. Their disagreeable dispositions accord well with their unpleasant and often repulsive facial expressions.

Their savage reactions and lack of intelligence have earned for them the reputation of being the lowest of the Old World monkeys. Baboons seldom assume the erect position for standing or walking. They do, however, sit upon their haunches in a somewhat crouched position, but not so freely as many other Old World monkeys. They all live in Africa, with a slight extension into Arabia. It is well that these animals never grew to the size of the great apes, for had they done so they certainly would have been among the most dreaded and frightful creatures ever known on earth.

Dr. Ditmars, who has spent much time in observing monkeys, reports many interesting studies and experiments concerning their behaviour. Apparently the habit of throwing missiles when enraged is not uncommon among baboons. Any angry monkey may in its rage grasp and hurl an object such as a drinking pan, but there is usually no accuracy in its aim or intention in its act other than an expression of irritated feelings. None of the monkeys has ever been known to use a stick or a club in attacking others or defending itself. Although the throwing of missiles is almost unknown among monkeys, the baboon marks an exception. As an instance, one day Dr. Ditmars found the visitors to the ape house almost in a panic, due to the savage behaviour of a big yellow baboon. A part of the cement had fallen out of the wall of his cage and broken up into sharp pieces. These pieces the baboon was hurling at the visitors through the bars in a most deliberately offensive manner and with effective aim. The crowd in consequence had retreated to various points of safety. Later a shovelful of coal was placed in the cage of this same baboon. The pieces of coal he also used as missiles, throwing them with calculating aim at the keeper and other attendants. The baboon seems to have an excellent throwing arm, and Dr. Ditmars credits him with good control and much speed. During this experiment a baboon of a different species acted in precisely the same way. In both of these animals their pitching capacity was demonstrated without any previous practice or instruction, and from these observations it would appear that baboons are natural-born pitchers.

Macacus, the Indian Monkey

Another one of the Old World monkeys, the macacus, shows a different side of the picture. He is more friendly, more gentle, more full of fun, and forever up to some sort of monkeyshines. Many of these monkeys live in India. Mr. Kipling has described them in his famous "Road Song of the Bandar-Log":

> Jabber it quickly and all together!
> Excellent! Wonderful! Once again!
> Now we are talking just like men.
> Let's pretend we are . . . never mind,
> *Brother, thy tail hangs down behind!*

These monkeys have their homes throughout the Indo-Malayan regions. They extend northward into China and Japan and eastward into Tibet. The macaques have a stout body and a proportionately large head. There is considerable variation in the tail, which ranges from a long, sweeping, plume-like appendage with a tuft at the tip, as in the lion macaque, to a thick, stubby tail much like that of a dog which has been docked. The pigtail monkey has a curled appendage. One of the macaques of Japan has a mere stump, while the Barbary ape has no tail at all. The macaques are the typical monkeys about which most of the favourite stories concerning the ape kind have had their origin. Their enormous cheek pouches, their facial grimaces, and the motion of their lips make them unusually fascinating to watch. They are extremely noisy, jabbering most of the time. They seem to have an extensive vocabulary of sounds, consisting of shrill calls, grunts, low mutterings, barks, chattering noises, and almost ear-splitting yells, which they emit in moments of rage. They are playful and quarrelsome, and these two phases of their behaviour pass without sharp line one into the other. They never become involved in serious combats because they seldom remain at one thing long enough to be effectual fighters. In their quarters at feeding time they usually make a real pandemonium in their frenzied efforts to stuff their cheek pouches as full as they can. They have absolutely no consideration or courtesy on these occasions. Their table manners are not only rough but actually ruthless, and the most delicious morsels go to the strongest. The weak, the young, and the female obtain what is left or go without. These monkeys are often docile and affectionate. They make the most amusing kind of pets. No animal is more mischievous or more destructive about a home where there is anything within reach to break.

Sometimes when they grow up they develop the unpleasant tendency of being too strictly a one-man animal. To protect their owner against an imaginary danger they will often attack strangers or visitors.

Behaviour of Macacus

The head of the macaque is much less dog-shaped than that of the baboon. The eyes are set closely together, and the animal sits on its haunches a good deal of the time holding its head upright, so that the eyes are directed forward. Its posture in sitting is quite human, while its attentive gaze gives the impression that it is watching intelligently all that is going on. Its nose is short and has a fairly good nasal bridge. The lips are thin and the upper one is particularly long. The hands and feet closely resemble human hands, except that the palm is not so broad, the fingers are longer, and the thumb shorter. In its movements the macaque is remarkably deft. It changes from one position to another with surprising swiftness. These monkeys go about in herds, often of considerable size. If captured young the animal is easily trained and quickly learns many amusing tricks. It is full of mischief and curiosity. Macacus monkeys frequently become a nuisance in the neighbourhood of towns where they live in large numbers. When full grown they are sometimes quite ill tempered and often savage even to the extent of attacking the inhabitants without much provocation. For the most part they live in cultivated tracts along the banks of streams. They seem to seek rather than avoid the habitations of man. They manifest little fear for their human neighbours and take a real delight in molesting them by many annoying pranks. Sometimes their attentions are vigorously resented and their human neighbours turn upon them. Their behaviour on such occasions is like that of tantalizing small boys who take an almost idiotic delight in the vain efforts of their pursuers to overtake them, and continue their aggravating antics in order to prolong the excitement of the futile pursuit. If one happens to be captured, a number of them will turn back to take the part of the unfortunate captive. In their native haunts they are constantly on the move. Repose is totally foreign to their daily programme. Scampering, swinging, chattering, screaming, they go among the trees all day long. Either their actions are without design, or else their purpose changes so rapidly and frequently that their behaviour has the appearance of ceaseless motion. When together they are very quarrelsome, constantly nagging or teasing each other, but here, as in all of their activities, the object of their anger, the victim of their jest, is as quickly shifted as their fleeting attention. Having no fear of the water, they are able to swim for long distances and greatly enjoy it. They feed upon spiders and many other insects, besides fruits and berries. As compared with the baboon, they show a greater mental alertness.

Mental Tests

Considerable psychological study has been made of the macaques, particularly concerning their ability to learn and their mentality. Dr. Kinnaman, who has made some of these studies, believes that they have attained a higher level of intelligence than that ascribed to the New World monkeys by Professor Thorndike. He thinks there is some evidence that the macaques have powers of reasoning, although of a low order. Dr. Hobhouse agrees with this view and adds that the macacus monkey seems to be possessed of definite ideas. Professor Yerkes, after a longer and more systematic study with experimental methods better suited to the problem, agrees with Professor Thorndike that the macacus may have a certain number of limited ideas. It is clear to him also that there are extreme differences in the mentality of different species of monkeys. The slow process which they display in the solution of problems is quite surprising, in many instances being actually less rapid than in some of the lower mammals.

One question is certain to arise at this point: How do the Old World monkeys compare in mentality with lemur and tarsius and with the monkeys of the New World? Perhaps the best answer to this question may be obtained by watching the actions of these different animals in their cages at the zoölogical gardens. Looking at a lemur as he jumps about restlessly among the supports of his cage, it is quickly concluded that this animal, not unlike a diminutive fox, is interesting only because of his remarkable agility. Tarsius would probably not be found in most zoölogical gardens because these animals do not survive long in captivity. The marmosets would attract little more attention than the lemurs, not only because of their small size, but also because of their lack of interesting reactions. Howling monkeys, spider monkeys, and woolly monkeys are more interesting because of the remarkable way in which they use their tails like a fifth hand. Their facial expression and their general behaviour, however, are somewhat monotonous.

The Old World monkeys, especially the macaques, hold the attention and create a real interest. Here is to be seen a busy world of jabbering, mischievous, tricky, athletic monkeys whose antics easily rival the best of human clowning. There can be no doubt that these Old World monkeys are on a higher mental plane than those of the New World. The main fault to be found with them is that they never get anything really done, except perhaps filling the pouches in their cheeks just as full as they can. Even the grouchy baboons show some signs of better mental powers than the South American monkeys. They have a thoroughgoing hostility for their human contemporaries which they have never changed, and their powers of organized banditry show a degree of mental capacity that is foreign to the lower monkeys. This capacity we should consider all the more noteworthy because the baboon manifests a distinct tendency to lose some of the benefits derived from living in the trees. It almost seems as though, to a certain extent, it had retrograded. This retrogression appears in the fact that many of the baboon's characteristics are less ape-like and more dog-like than other Old World monkeys and also because its hands and feet seem to be specialized more in the direction of paws. Yet, in spite of this backsliding on the part of the baboon, the monkeys of the Old World are as a whole eminently more efficient in their actions and capacities than any of the New World monkeys, the lemurs or tarsiers.

Brains of the Old World Monkeys

A question may arise concerning the relation in point of time which the Old World monkeys bear to those of the New World. All of the evidence supplied by fossils indicates that lemurs and tarsiers, as well as the monkeys of South America and Central America, came into existence long before those species which inhabit Africa and Asia. According to most reliable records, the monkeys had their start some time early in the Age of Mammals. It is correct, therefore, to look upon the Old World monkeys as a later and higher stage of development in apedom. This conclusion is borne out when we view the brains of the macaque and the baboon. In this comparison we may be able to detect many signs indicating improvements in the brain; in fact, all doubts may be set at rest concerning the superiority of Old World monkeys.

If we look at the baboon's brain we are impressed by the fact that it has many more grooves and many more convolutions than the brain of the South American monkey. The convolutions and the grooves of the brain indicate the amount of cell space which the superbrain provides for developing brain power.

As between the baboon and the macaque, the difference in this respect somewhat favours the former. This difference is small and may perhaps be discounted by the fact that in macacus the grooves have a slightly more advanced arrangement in consequence of which certain departments of the superbrain show more progressive tendencies than in the baboon. This is particularly true of the department of hearing (temporal lobe) and the department of body and contact senses (parietal lobe). Comparing the groove of Sylvius, whose general angle furnishes such an important standard in rating a brain, there is more of a backward tilting seen in this groove of the macaque than in the baboon. Such an inclination is characteristic of higher races. The central groove appears to be about on a par in both brains, and the ape groove is likewise well developed both in the macaque and the baboon. These three great boundary lines separate the four major lobes of the superbrain. The department of sight in the occipital lobe in macacus has no real advantage over the corresponding area in the baboon. As already noted, the departments of hearing and of body and contact sense are better organized and somewhat more expansive in macacus than in baboon. But when we come to the preëminent part of the superbrain, that portion in which the chief executive function is located, namely, the frontal lobe, the baboon actually seems to have some real advantage. Recalling the ugly disposition and ferocious nature of this animal, we may question why he is superior in this highest part of his brain to the lively and humorous little macaque. It is unfortunate that we have not as yet any good psychological studies of the baboon by which we may compare him with his more nimble associates. Doubtless it is the disagreeable nature and uncompromising aversion which the baboon has for mankind that make it so difficult to estimate him psychologically. Yet there may be something of an enviable consistency in the baboon's aversion to man that implies a better type of mental power than one might infer from the jabbering, ceaseless activities of the macacus and all of the other bandar-logs. Some explanation of this sort must at present suffice until we are possessed of better standards for psychological comparison.

The two important structures on the base of the brain furnish a definite idea of an animal's rating. Accepting their evidence, it appears at once that the bridge (*pons*) bears out our previous observations concerning the powers of the superbrain. This evidence gives the baboon a higher standing in intelligence than the macacus. The value assigned to the bridge in the baboon is .164, while in the macacus it is .150. This contrast gives an interesting corroborative estimate of the superior mental powers of the baboon. From the figures indicating the relative size of the pryamid, it would seem that the macacus is somewhat more richly supplied in his variety of skillful movements than the baboon. The figure in macacus is .147 and baboon .143. While this is not a marked difference, it seems to indicate an advantage probably derived from the more nimble and acrobatic actions of the macacus. This animal has acquired a more highly efficient mastery of tree life as compared with the more sluggish tendencies of baboons, most of which prefer to live upon the ground and go about like other four-legged animals. These contrasts between the Old World monkeys are interesting for what they show in themselves. They give rise to many questions which we would be glad to see answered by more exact and extensive study. The reasons why the baboon or the macacus should be endowed with superior qualities in one particular or another, or why there should be corresponding improvements in the brain, are not clear. There can be no doubt, however, that in the Old World monkeys as a whole both behaviour and brain are in many respects superior to the monkeys of the New World. We cannot fail to discern the special points of this superiority in the brain. It seems impossible to avoid the conclusion that when the Old World monkeys made their appearance they definitely advanced the cause of progressive improvement and that from this progress the brain profited as much as or even more than any other part.

Turning back for a moment to the brains of the New World monkeys and comparing them with those of the Old World group, we will find sufficient evidence to convince us that the chief organ of the body was surely on the way upward, and that the first humble steps taken by the earliest members of monkey kind had been supplemented by further and bold advances.

CHAPTER VIII

MANLIKE TENDENCIES

BRAINS OF GIBBON AND ORANG-OUTANG

THERE is little about the Old World monkeys, either in their mode of life or in their appearance, to inspire respect or confidence. The savage fierceness of the baboon, the mischievous nonsense of the macaque, seem like flimsy foundations upon which to build a race of intelligent human beings. When these animals first made their appearance they were but vague foreshadowers of what mankind might be. It is not alone their form and structure that interests us; their actions, habits, and behaviour must be carefully studied at the same time.

The Anthropoid Gibbon

Had the human eye been able to observe all that transpired in the early days of the monkey kind, it would have been difficult to believe that a race of men was in the making. It would have seemed incredible that from these chattering, restless monkeys change and modification could eventually bring forth that development necessary for the human form. And yet in the course of time changes of this kind did bring into existence an ape which bore a much closer resemblance to man. It was then possible to foresee how, from this new kind of animal, certain human features might be derived. This particular member of the ape world is the gibbon. All of his tendencies make him somewhat shy and inconspicuous. At the zoölogical gardens he is generally sitting high up on a perch in his cage with his long arms folded over his head, peering quietly about him. His fur is usually dark, although some members of his family are quite light in colour. The most impressive thing about the gibbon is the fact that he can stand up, walk, and run upon two legs. This he does a little awkwardly, but not unlike a human being. In a certain memorable moving picture, an unusually interesting silvery gibbon nearly usurped the rôle of leading man. His marvellous feats earned for him universal applause, and whenever he appeared he was the centre of attention. Among its most stirring moments, this picture shows a dramatic scene in which a great Indian elephant whose young one has been captured demolishes the dwelling of the jungle native who has trapped her offspring. Shortly after the native with his wife and children has escaped to safety, the gibbon emerges cautiously from the wreckage of the home. Through the darkness of the forest he discerns the glistening eyes of a tiger that is about to spring upon him. Realizing that retreat is cut off, he takes to flight. In escaping he stands upright and runs like a man, screaming in his fright in a thoroughly human manner. Fortunately for the gibbon, the branch of a tree comes opportunely in his path, and then, with a single upward bound, he is off like a bird through the trees to safety.

Gibbons are gentle, affectionate creatures. They are also timid and at the first sign of danger hurry away through the forest as far up in the trees as they can go. The gibbon's body and head are relatively small, being only a little larger than some of the smaller macaques. The animal's legs are short and it has no tail. A prominent feature is the exceptional length of the forearm and of the fingers. The hand is slender and longer than the foot. The female bears one young at a time, which the mother carries under her body, the young one clinging to the fur on her chest with hands and feet. This burden does not embarrass her in the slightest as she swings her way from tree to tree through the forest. She makes as good time in this transportation as the unincumbered males.

In the wild state the gibbons never leave the jungle, and live for the most part throughout southern Asia and the adjacent islands. A few of them venture from the inland forests to the vicinity of the coast. All of the gibbons are highly developed for life in the trees. This specialization is important not only for the effects it has had upon these apes but also for those developments in them which were to be of subsequent and substantial advantage to the rise of man.

There are many different varieties of gibbons such as the white-handed gibbon, the silvery gibbon, the white-cheeked gibbon, the slender gibbon. The animal that we shall consider is the hoolock gibbon of India. He gets his name from a peculiar sound or cry which he makes. If it were at all possible to imitate this cry it might be expressed as "hooloo! hooloo! hooloo!" Mr. Candler has studied this interesting animal at close quarters, and his account of its habits is well worth quoting:

> The Hoolock swings along the thinnest part of a bough or to the slender end of a bamboo, until it bends to its weight, then with a swing and a sort of a kick-off he flies through the air seizing another branch, and swinging along it with the accuracy of a finished trapeze performer. I fancy he does very little walking in the wild state, for I have never seen a wild Hoolock on the ground. Moreover, they are only found in the dense jungle where the ground is everywhere covered with tangled vegetation. The Hoolocks are extremely shy and it is difficult to watch them as they are concealed by leaves high up on the bamboo clumps or tops of forest trees. The cry of the Hoolock is characteristic. It is a very pleasing note, rising and falling in intensity, and reminding one somewhat of a pack of beagles giving tongue on a scent, which is waxing and waning in strength as a larger or smaller number of the band join in the chorus. It is heard chiefly in the early morning, then through all the heat of the day there is silence, but towards evening as the sun sets you may hear it again.

One might almost think that their early morning cry was like a rising bell, and their cry toward evening was their curfew.

Manners of the Gibbon

Gibbons live in fairly large communities. They are constantly on the move. From what is known of their intelligence it seems probable that their movements are guided by definite plans. They even seem to have some simple sort of governmental system. Tea planters in India often keep these gibbons as pets for years.

They run about the compound quite freely. At times they suddenly disappear and are gone for several months. Eventually they return quite unconcerned, as if nothing had occurred to interrupt their pleasant human associations. For the most part the gibbon is sociable. After he has become acquainted he will often sit on the arm of a person's chair at breakfast. Whatever his appetite, he will never reach out for food at the table, although his long arms give him much advantage over his human host. Nor will he ever snatch things off the table. His manners are above reproach and he keeps himself scrupulously clean. As the day is drawing to a close it is his habit to get ready for the night. At sunset he settles down to sleep, safely seated in the fork of a tree, usually with his long arms over his head. He is never boisterous, mischievous, or noisy. Oftentimes he seems to be more in sympathy with children than with grown-ups.

The diet of the gibbon includes a long list of foods, such as fruits, leaves, and young shoots, spiders, birds' eggs, insects, and young birds. If captured young the gibbon is readily tamed. He is never sulky or ill tempered and shows marked intelligence both in learning many tricks and adjusting himself to the rules of the home.

The locomotion of these animals among the trees is totally different from that of the monkeys. The latter climb about using both hands and feet. Gibbons employ their arms almost exclusively, swinging from branch to branch, with the legs tucked close to the body. This is such an important change in the transportation methods of apedom that we should give it particular attention in order to note what effects it had produced upon the gibbons themselves. In the first place, swinging from one limb to another by the hands greatly elongated the forearm and the fingers. This kind of locomotion gives the gibbon the appearance of taking tremendously long strides with his arms. The right hand, first grasping a branch, permits the animal to swing twelve or more feet to the next branch which is grasped by the left hand. In the next step the forward stride is taken by the right hand. Thus the animal alternates the right and left hand just as we alternate the right and left foot. It is probably for this reason that the gibbons have been called "tree walkers" (*Hylobates*).

The second effect produced by this kind of swinging locomotion, called brachiation, is even more decisive in the final outcome. Transportation such as this swinging by the hands drew the body more and more into the upright position. It brought about many of those fundamental changes which made it possible for the gibbon to stand upright, walk, and run upon two legs. Compared with other animals of this class, the gibbon is the most two-legged of all the apes. He walks rather quickly in the erect posture. His gait is waddling, and if pursued he will make every effort to reach some support by which he can swing himself to safety. In walking he turns his leg and foot outward, which gives him a bow-legged appearance, added to which the shortness of his legs makes his movements in walking and running far less graceful than these acts ultimately came to be in their highest exponent, man. Here undoubtedly may be discerned important elements for the inception of human locomotion. They appear in an animal which can stand, walk, and run upright, and also possesses well-developed hands.

Gibbon's Resemblance to Man

The gibbons are said sometimes to scoop up water in the hollow of the hand in order to drink. At other times they stretch out their long arms among the foliage and lick off the dew which adheres to their hair, in this way quenching their thirst.

In view of these facts our estimate of the gibbon may credit him with certain manlike traits. Yet his resemblance to human beings, considering the animal as a whole, is at best sketchy and vague. Casual observation of the gibbon does not bring any clear association with the human being at once to mind. Only after watching him, after noting the manner in which he gets about, after seeing him walk and run on two legs, is it possible to recognize certain tendencies which point in the human direction. It is for this reason that the gibbon is said to represent a stage preceding the manlike apes. Some students of this question class the gibbon with these anthropoid apes. It seems better judgment, however, to consider him rather an animal showing dispositions which serve as a starting point for the anthropoids. These tendencies, as they are crystallized in the gibbon, represent an introductory chapter in the history of all those animals which later became notable because they walked more or less upright and had the use of hands. Thus the gibbon is often spoken of as pro-anthropoid. He himself is a modern animal. One of his venerable ancestors, very much like himself, lived long ago—*Propliopithecus* of the Oligocene. The descendants of this ancient extinct ape with the long name, whose fossil remains have been found in Egypt, followed two lines of development. One line led up to the modern anthropoid apes and man, the second to the modern gibbons. The first offshoot from this line gave rise to a great ape which in many features looks much more like man than does the gibbon. This is the orang-outang. He is one of the big apes seen in the large primate cages of the zoölogical gardens. He may be recognized by the brownish-yellow hair which covers his body, by his face which bears a humorous caricatured resemblance to man, and by the erect posture which he assumes much of the time. Although he climbs about his cage and its supports like a skillful acrobat, this manlike ape lacks the grace and agility of the gibbon. He is wild and shy, but possesses enormous strength, which makes him more than a match for the most able-bodied man.

The Orang-Outang

The orang lives in Borneo and Sumatra. He has not been found elsewhere in the world. In his island home he enjoys a deserved reputation because of his prodigious strength. When full grown he stands a little over four feet in height. He has a heavy body, short thick neck, receding forehead, thick lips, and a face uncovered by hair. His muzzle protrudes to form a thick and heavy upper jaw, with a large mouth and large teeth. In the full-grown male the cheek pouches become greatly enlarged, so that they look like an old-fashioned ruff around the head. This feature gives him a hideous and gruesome appearance. The arms are long, reaching almost to the ankles when the orang stands upright. The hands are long and narrow, the thumb is short, the fingers are united by webs at their bases. The legs are short in comparison to the length of the body and considerably bowed. The feet are long and narrow. The great toe is short, but it can be used for grasping the branches. Fleshy pads over the buttocks are present in the adult male, but the orang has no tail. He is easily distinguished from the other great apes by his bulging muzzle and his light yellowish-brown hair. He seldom exceeds four feet two inches when standing upright, but his outstretched arms together measure nearly eight feet from finger tip to finger tip. Some specimens killed by hunters have been reported to stand five feet three inches high.

Among the first accurate accounts of the orang-outang's life is that of Alfred Russell Wallace appearing in his famous book *The Malay Archipelago*, from which the following description is an extract:

> The orang has a wide distribution, inhabiting many districts along the coast of the island [Borneo] where it appears chiefly confined to the low swampy forests. It particularly affects a country which is low and level with a few isolated mountains,

on some of which the Dyaks have settled and planted many fruit trees which are a great attraction to the orang, as his most desirable food seems to be unripe fruit. The habitual habitat of the animal is in the lofty virgin forests, in which they can roam in every direction with as much facility as the Indian on the prairie, passing from treetop to treetop without being obliged to descend to the earth. The orang makes his way leisurely through the forest, with remarkable ease. He walks deliberately along the larger branches, in a semi-erect attitude which his great length of arm and the shortness of his legs causes him naturally to assume. But this proportion between his limbs is increased by his walking on his knuckles and not on the palm of his hand. He chooses those branches which intermingle with those of an adjoining tree. In approaching these he stretches out his long arms, seizing the neighboring bough with both hands and then deliberately swings himself across to the next branch, on which he walks along as before. He never jumps or springs nor even appears to hurry himself, yet he manages to get along almost as quickly as a person can run through the forest beneath. The long powerful arms are of greatest use to the animal, as they enable him to climb easily the highest trees, to seize fruit and young leaves from slender boughs which will not bear his weight and to gather leaves and branches from which to form his nest at night. When wounded he endeavors to make a nest in which to remain quiet, and similarly at night prepares a resting place in the tree to sleep. He likes this place low down in the tree, not over 20 or 30 feet from the ground, probably because in this position it is warm and less exposed to the wind.

The orang, it is said, makes a new nest for himself every night or perhaps remakes an old one. In rainy weather the animal covers himself with leaves or large ferns, and this may have led to the belief that he actually builds huts in the trees. The animal does not arise from his bed in the morning until the sun is well up and has dried the dew upon the leaves. He seldom returns to the same tree two days in succession.

They have no particular fear of man, and only retreat slowly after a considerable period of scrutinizing inspection. They do not have so much of the gregarious tendencies as do the other large apes. Two full-grown animals are seldom seen together, but males and females are sometimes accompanied by half-grown young ones. At other times three or four young animals are seen together. Their food consists almost exclusively of fruits, leaves, buds and young shoots. They seem to prefer the unripe fruit, even when very sour or intensely bitter, the red fleshy arillus being a particular favorite. The orang rarely descends to the ground except when pressed by hunger, when it seeks the succulent shoots at the riverside. In very dry weather it also comes down from the trees in quest of water, of which it generally finds sufficient in the hollow of the leaves. They have been seen upon the ground playing together, at which times they assume the erect posture and grasp each other with their arms.

Wallace believes that the orang seldom stands or walks erect unless when using its hands to support itself by the branches overhead, or when attacked. He also thinks that the representations of it walking with a stick are quite imaginary. In its general demeanour the orang would impress one as dull and apathetic. When seated among the branches its back is bent, its head is bowed, and its long arms either reach up to grasp a branch overhead or hang listlessly by its sides. Some explorers have maintained that the animal builds huts for itself in the trees. This is largely an exaggeration, but the orang has developed an interesting technique for building itself a nest in the trees as night approaches. Small branches are first laid crosswise to form a framework, and over this a thick bed of leaves is placed. The orang is quite fussy about the construction of its bedroom and takes good care to cover itself up when the wind is chilly or the night stormy. Even in captivity the animal is particular about the details of its bedchamber and always manages to cover itself with straw or newspapers if it happens to find them in the cage.

The orang has other constructive tendencies. He often manifests some engineering skill in devising supports for himself in his cage. With these he will amuse himself by the hour, climbing upon the support, dropping to the floor, and repeating the entire performance time after time in as many different ways as he can. In one instance a young male orang found a long rope hanging from the roof of his cage. He clung to the rope by his left hand and both feet. With his free right hand he passed the end of the rope around the bars, turned it through a right angle, and pulled it tight. In this way he made an interesting perch for himself. If anyone detached the rope he at once replaced it and thus remade his perch.

On the ground the orang is clumsy. He usually goes on all fours, and his walking gait has been likened to that of a very old man bent down by age, hobbling along with the aid of a cane. It is interesting to note that in walking he goes on the outer borders of his feet. His stride is short and shuffling. Even when hurrying he lopes along rather than runs. Unlike the gibbons, the orang does not use his hand as a drinking cup. His lower lip protrudes in a capacious trough for collecting rain water. If given a pail of milk or water the orang lifts the pail and pours the fluid into this trough and then swallows it. When captured young the animals can be trained and taught to obey many words of command. In time they get over their shyness and seem to like human companionship. They are, however, easily frightened. Females when pregnant separate themselves from the others and remain more or less in seclusion until the young are born. The offspring grow slowly and, like human infants, require the care of their mothers for a long time. When the mother moves about the young one clings to the hair of her chest. This is a marked characteristic of child care throughout the ape world.

The Orang in Infancy

Wallace recites an interesting experience which he had with a baby orang whose mother was shot and killed by him in the forest the preceding day. This experience is especially interesting because of its many human resemblances. When Wallace stooped to pick up the helpless infant orang that lay sprawling on its back, his long beard was immediately seized by the grasping hands and feet of the youngster. It was a long and painful ordeal to get away from this clinging infant. The baby orang had but a single tooth, but soon its milk teeth began to appear, much as in a human infant. The lack of milk on the island made it difficult to feed the young ape. When a finger was placed in its mouth it would suck with great vigour, drawing in its cheeks in a vain effort to extract milk. After persevering for a long while it would give up in disgust and start screaming, much as would a human baby under similar circumstances. When handled or nursed it was always quiet, but if laid down by itself it would invariably cry. It enjoyed being rubbed after its morning bath and was quite happy while its hair was being combed and brushed.

For the first few days it clung desperately by all four hands to everything it could reach, and Wallace remarks that it was necessary for him to be cautious in keeping his beard out of the way. He felt that the infant ape was lonely and needed companionship, so a little harelipped monkey of the macacus variety was obtained as a playmate. It was curious to see the difference in the actions of these two animals, the one an offspring of a humbler monkey, the other born of one of the great manlike apes. The two young ones were about the same age. The orang, just like a human baby, would lie upon its back helplessly rolling from side to side, stretching out all four hands into the air and striving to grasp something, although hardly able to guide its fingers to any desired object. When dissatisfied it opened wide its almost toothless mouth and expressed its discomfort in an infantile scream. The little macacus monkey, on the other hand, was constantly on the go, running and jumping about, examining everything in sight, taking hold of objects with greatest precision, balancing itself on the edge of its box and searching everywhere for food. There could scarcely be a greater contrast. One could hardly escape the conclusion that in the orang, as in man, a long period of slow growth is necessary for its final development. The advantages of such growth are sufficiently apparent and need no further comment.

Psychological Tests

The orang-outang has not yet been so extensively subjected to psychological study as its more sociable fellow ape, the chimpanzee. It is fortunate, however, that at least one of this species has come under the critical observation of an astute student of animal behaviour, Professor Robert M. Yerkes, of Yale University. In his notable contribution on the mental life of monkeys and apes, Professor Yerkes has described certain tests devised for estimating the intelligence of lower animals, and applied to the partly grown orang known as "Julius." These tests were devised on what is known as the "multiple choice basis." Julius, after many unsuccessful efforts to solve his problems by the method of trial and error, quite unexpectedly seemed to get the idea of what was wanted. He suddenly responded to the test without a single mistake. He seemed to solve his problem quite as if he knew what it was all about. It took him a long time, but at last he showed that he was capable of some kind of thinking. The curve of learning as it was charted day by day from the actions of Julius indicated that if he had been a human subject his mental process would possibly have been described as rational. Professor Yerkes feels justified in concluding from this evidence that the orang solves his problems ideationally. In general, Julius appeared to be far superior to other monkeys in his intelligence. His mental processes were slow, but the method of learning by ideas seemed to replace the simpler way of trial and error which is common throughout the monkey world. Julius persistently endeavoured, and often vainly, to gain some insight into a situation. Even though slow, he showed nevertheless that the brain had at length attained the development necessary for the production of real ideas. However questionable this attainment may be in the monkeys or in other lower animals, there seems to be little doubt about its existence in the orang.

Brains of the Gibbon and Orang

Upon reviewing the facts concerning the gibbon and the orang, we may ask certain questions. For example, does the real progress which these two members of the ape world show in their capacity to do things manifest itself as a measurable difference in their brains? Would it be possible to maintain that these were indeed the brains of more capable and more intelligent animals than the monkeys? Certain features about the brain of the gibbon and the orang are striking. In the first place, the pattern of their convolutions is more complicated. The orang especially has more grooves and convolutions upon the surface of the superbrain. It is believed, and many facts sustain the belief, that convolutions indicate in a general way the capacity of an animal to develop brain power. In the gibbon the increase in convolutions is not so pronounced as in the orang, although it is not difficult to see that in this respect the gibbon's brain is much improved when compared with lower monkeys. Upon identifying the familiar landmarks, it is obvious that the groove of Sylvius, the central groove, and even the ape groove form more decisive boundaries and outline more prominent lobes than in macaque or baboon. The superbrain departments for sight (occipital lobe), for hearing (temporal lobe), for body and contact senses (parietal lobe), are all more extensive. Each lobe, by the presence in it of smaller secondary grooves which do not appear in the lower monkeys, shows how its capacity has expanded. The grooves of the brain, in their arrangement, number, and relations, now begin to assume an appearance similar to that of the human brain. Each sense department in the orang is well organized. Each has gained in prominence, thus indicating how the senses of sight and hearing, and body and contact senses, have increased their capacity. By means of its amplified sensory combinations the superbrain was eventually capable of producing intelligent reactions. The area in front of the central groove manifests the chief improvement. This is the part of the brain in contact with the frontal bone. It has made some advances in the gibbon but is still more prominent in the orang. At this stage it is possible to speak of a well-developed frontal lobe acting as the headquarters of all higher mental functions. The large increase in the size of the orang's brain is in some degree proportional to the size of the animal's body. Many other factors have actuated this expansion and will receive special consideration in a subsequent chapter.

If it were possible to reduce the difference in intelligence between the orang and the gibbon to actual figures, the contrasts would be marked. Certain estimations of this kind are significant. The bridge (*pons Varolii*) on the base of the brain, which may be regarded as an index of intelligence, has a value of .200 in the gibbon and .300 in the orang. The pyramid, indicating the degree of skill in movement attained by the animal, as well as the degree of controlling itself by the dictates of its will, also shows a considerable difference. This difference is again in favour of the orang, whose pyramid is estimated at .160, while that of the gibbon is .138.

Many other points indicating similar advantages held by the orang over the gibbon might be cited. They have the same general meaning, namely, that the orang possesses a better brain. In fact, all of the evidence gathered from this animal reveals many manlike tendencies. Such tendencies, both in brain and behaviour, first became notable in the gibbon. At this stage they were not prominent features. They were, so to speak, in a preparatory or pro-anthropoid phase. In the orang those manlike tendencies foreshadowed by the gibbon became more definite and better developed. They formed the foundations for new combinations out of which was to emerge a still higher type of animal.

CHAPTER IX

HUMAN IN MINIATURE

THE BRAIN OF THE CHIMPANZEE

THE chimpanzee has a well-established reputation for many sterling qualities. He is a comedian of no mean talent, and often as a buoyant fun maker earns a large salary. He is also famous as an acrobat.

Depending upon his species, the chimpanzee varies in height from four feet to four feet five inches. As a class these apes are spread out over more territory than any of the other great anthropoids. They live in West and Central Equatorial Africa ranging from Gambia in the north as far south as Angola. In colour they are black with thick hair over the entire body, except the brow and face. In some species the scalp is bare, as in the bald-headed chimpanzee. All varieties are powerful but lightly built animals. They possess great strength and agility. In spite of his relatively short stature, the chimpanzee is a dangerous enemy even for the strongest man. His head is flattened in the region of the forehead, which has a thick bony ridge above the eyes. The ridge of the nose is flat. The mouth is large and the lips thick. The ears are especially large and project upward almost as high as the vertex of the head. The lower jaw protrudes considerably. The teeth in general are large and formidable, the canines in particular being prominent. The skin over the face is usually dark, but in some species it is lighter than surrounding areas. This is particularly true in the region of the mouth and nose. The body is short and the abdomen pendulous. The legs are shorter than the arms. The foot is short with a great toe that is thick and opposable. The other toes are united by a web near the base. The arms are long, with finger tips reaching a considerable distance below the knees when the animal stands erect. The hands are broad, the thumb is short, and the fingers webbed near their bases, as in the case of the toes. As is true of the other great anthropoids, the chimpanzee has no tail. The female bears one young at a time, which she carries when passing through the forest and along the ground in the manner characteristic of other apes.

Intelligence of the Chimpanzee

Concerning the habits of the chimpanzee in its native state little is known. Fortunately, many of these animals have been captured when young. Some of them have become noted circus performers, or famous moving-picture actors. A number of them have been studied from the standpoint of their behaviour and psychology. One of the best records of the chimpanzee comes to us as an echo of the Great War. It furnishes another instance of German thoroughness and scientific enterprise.

Some years ago the Prussian Academy of Science established at Teneriffe in the Canary Islands a special station equipped for the study of the great manlike apes. It was here that Professor Köhler found himself during the Great War and here he remained interned with nine chimpanzees for two years. During this time he lived with these animals largely shut off from the rest of the world by the naval blockade. The report of his experience and studies is given in a delightful narrative published both in English and German called *The Mentality of Apes*. The following descriptions of the chimpanzee are taken from Professor Köhler's book. In this work his chief purpose was to test the intelligence of the larger manlike apes. To this end it was necessary to devise certain methods which he called "roundabout tests" because they complicated ordinary situations in such a way as to require intelligence on the part of the animal for their solution.

Early in the study one of the most quick-witted chimpanzees in the collection was given the following problem: From the roof of the animals' playground a basket of bananas was suspended by means of a string passed through an iron ring. The end of this string was tied in a noose and placed over the limb of an old tree at a height of nine feet from the ground. When all was ready, the chimpanzee called "Sultan" was sent out into the playground. He, of course, was familiar with this basket and associated it with feeding time. On entering the enclosure Sultan saw the basket at once and then began to manifest signs of agitation because, contrary to custom, he was all alone in the open. He began at once to show his feelings in true chimpanzee style. Jumping about he expressed his extreme disapproval at being alone by making a thundering noise with his feet against the wall of the ape house. It seemed as if he were calling upon the other chimpanzees to come out and join him. He even tried to get in communication with the other animals by climbing up and looking in at their windows. But all of this was to no avail. Presently he appeared to take a renewed interest in the bananas. He looked up at the basket, and having sized up the situation made for the tree, climbed quickly to the noose, pulled the string until the basket bumped against the roof, released the string, pulled it a second time even more vigorously, until a banana fell to the ground. Sultan then left the tree, but soon ascended once more, now to pull violently upon the string until it broke and the entire basket fell. Immediately he scampered down, took the basket, and went off in a corner to eat the fruit. Thus Sultan, in a comparatively brief time, solved this roundabout problem by obtaining the objective in spite of the obstacles put in his way.

The Chimpanzee's Use of Implements

Many experiments were made to see how much the chimpanzees make use of implements, but in the main these experiments were not necessary. The chimpanzee, as if by nature, handles many objects in his immediate surroundings in a variety of ways. His powerful hands serve in a most natural manner as a useful link between him and the world of things outside. His feet, although far more than a second pair of hands, may be used in emergencies when the human feet would be quite useless. The jaws and teeth are also serviceable, and are employed as among many African tribes and other primitive people. The handling of everyday objects by the chimpanzee comes almost entirely in the nature of play. Sometimes under the pressure of need it appears that new knowledge acquired from using objects at play will be put to still better use in gaining some desired objective. In the main, however, what the chimpanzee may use in this way is without the slightest idea of immediate gain and serves only to increase the joy of living. Thus jumping with the aid of a stick or pole, invented by one of the brightest chimpanzees, was imitated by all the others as a means of entertainment. Later it was put to more practical use for obtaining food which was suspended above them and out of reach. In order to get this food it was necessary to resort to some means of lifting their body toward the desired goal. In the end the jumping with a stick in play was converted to a sort of pole vaulting by means of which the chimpanzees all acquired a thoroughly businesslike method for getting such food as was out of reach over their heads. These chimps also used straws and twigs as we use spoons. At first this was more or less in play during mealtime, especially after their first thirst had been quenched. Then they liked to amuse themselves by dipping the water up with a straw and sucking the straw. Once some red wine was poured into the drinking water which they shared in common. At the first taste of this new mixture they all paused for a moment and looked at each other; then one of the chimpanzees began to spoon up this wonderful drink with a straw, and all the others immediately followed his example. In learning to use twigs and straws for spoons there was no possibility of imitation. None of the chimpanzees had a chance of seeing a human being use a knife or spoon while eating. The twig or stick was also employed quite deftly in other ways, adding to its usefulness as a table utensil some of the properties of a weapon for the chase. In the summer time a species of ant infests the part of the Canary Islands where these great apes were housed. These ants passed in a wide stream, moving along over the beams, around a wire netting which encircled the playground. The chimpanzee has a great liking for acid fruit, which he prefers to all others. It is no doubt for this reason that he relishes the formic acid in the ants. Usually upon seeing the ants the chimpanzee simply rolled his tongue along a beam over which they were crawling and thus gathered them in to himself. If the wire netting came between him and this coveted delicacy, such a method of capture would not suffice. In consequence, all of the chimpanzees soon learned to use sticks and straws, which they thrust through the wire netting and held in this position until covered by ants. The straws were then withdrawn, and the insects promptly licked off and devoured. This method of capture proved most satisfactory and entertaining. Their attention was entirely absorbed in the process of overcoming the obstacle between them and the delicate morsels which they craved.

Strong Human Resemblances

If a mouse, a lizard, or some small crawling animal entered the playground, the chimpanzees at once became greatly excited. They manifested all of the hunting interest apparent in the human species under like circumstances. There was also evidence of fear and timidity on these occasions, not, however, confined to the female alone. Even the bolder chimpanzees that evinced the greatest hunting interest did not give chase with any creditable show of courage. They manifested caution and hesitation throughout the entire performance. Nearly every movement on the part of the poor quarry was followed by nervous gestures of the chimps. The largest ones hesitated to make a capture by a sudden snatch with the naked hand. It was amusing and almost laughable to see these powerful apes stretch out their hands with the evident intention of catching the prey, with fingers all pointed in anticipation, then suddenly, on the slightest movement of the mouse or lizard, quickly withdraw the hand again. A firm grasp upon one of these little wriggling animals appeared almost as impossible for the chimpanzees as for many people. Despite the great excitement which the presence of invaders occasioned, the little animals would often escape because the chimpanzees lacked that last degree of daring necessary to make a successful capture. Presently they learned to use sticks upon the small intruders of their domain. With these weapons, if the victim did not escape, they would at length dispatch it. This they did in no spirit of cruelty but rather in sheer excitement of the chase.

Professor Köhler took great pains to observe the rapidity with which the chimpanzees adjusted themselves when confronted by new conditions for the first time in their lives. One of the most striking tests of this kind was their introduction to the electric current. It was decided to observe how the chimpanzees would act when they made the acquaintance of this entirely new circumstance. For this purpose one wire from an electric induction coil was attached to a metal basket filled with bananas and suspended from the roof. The other wire from the battery was made fast to a metal netting upon the ground beneath the basket. In a short time all of the chimpanzees became intensely interested in the fruit above their heads. They were particularly eager to reach the bananas. To do so it was necessary for them to stand upon the wire netting on the ground. At first one chimpanzee approached cautiously. Having taken up his position with both feet upon the wire netting, he reached slowly up to the metal basket. This of course immediately made a connection which delivered an electric current through his hand. The reaction of the chimpanzee was astonishingly human. Immediately upon touching the basket he felt the shock of the current and with a cry of dismay bounded off in great surprise. His curiosity, however, was not yet satisfied. He still had a hungry longing for the bananas. Everything about the situation looked thoroughly familiar and innocent to him. He could see no reason why the basket on this occasion should treat him so rudely or why he experienced such an unpleasant sensation in trying to get his food as he had done a hundred times before. Appetite and curiosity finally got the upper hand, and stealing up cautiously he made a second attempt. This time he was less hasty in grasping the basket and spent several moments in hesitating attempts to touch it, drawing his hand back now and again. At length, with a sudden grasp, he reached for the goal, only to receive another shock. In apparent indignation he hopped away in much the same manner as might any human being who had inadvertently touched a hot stove. Nothing would do, however, but that all of the chimpanzees in turn should follow the example of their leader and try to get the bananas away from this strange thing that seemed to be outwitting them. One after another they made their futile attempts until it became a pathetic sight to see them sitting around in a mournful ring, sometimes looking at their hands, sometimes shaking them resentfully, and always gazing wistfully at the inaccessible delicacies. Most of the chimpanzees during this test reacted in a manner which might easily be called human. It was rather impressive to observe that all of their reactions under these conditions were actual counterparts of human behaviour.

Chimpanzee Sports and Nest Making

In handling other objects the chimpanzees showed a strong tendency to develop new habits. After a time they did not confine themselves alone to thrusting and hitting with sticks. They soon began to throw them around. In moments when they were greatly pleased (and chimpanzees have a joyful, buoyant nature) they showed their delight in a new way, especially when very good food was being provided. On such occasions one of them would seize another and shake him violently out of sheer pleasure and approval. Under such provocation a large chimpanzee developed the habit of taking a stick and flinging it forcefully at some comrade in his vicinity. This frequently happened in play also. One female, a remarkable athlete called "Chica," developed the amusing pastime of stealing up behind her companions as they sat quietly at rest, and from fairly close quarters hurling a stick at them. Immediately she would scurry off, apparently much delighted by the discomfort that she had caused. From throwing sticks it was but a short step to throwing handfuls of sand at one another, and finally stones of varied size and weight. At first their aim was poor, but soon throwing stones became a ruling passion among them, and some of them became dangerously expert, especially the wily Chica. She practised so continuously that she soon acquired great skill and an excellent aim. From this pastime she appeared to derive much satisfaction, whether hurling stones at her fellow apes or at her human associates. Both ape and man acquired such a genuine respect for her ability in this regard that whenever they found her in this mood they quickly retired to safety and permitted the expert marksman to find her amusement on less sensitive targets. All of these hurling activities, which were in the nature of play, might for a few moments determine an exciting stone battle. But the sharp-shooting Chica was so obviously superior that the fray was certain to be short lived.

Almost all of the chimpanzees made nests for themselves, even from the earliest infancy onward. In these operations, as might be expected, the full-grown chimpanzee made the best beds. It may not be altogether clear why the adult female was the best chambermaid of all. Her efforts in bed making did in fact show a precision in tidiness that was unequalled by any of the others. Usually in the evening, as the strenuous play of the day subsided, all of the apes began to gather heaps of straw. In the centre of each heap a chimpanzee would sit quietly and begin to twist the ends of the straw together. This work continued all around the edge until a natural nest, not unlike that of the stork, was formed. The younger animals in their nest making were less exact. They seldom made so neat a turning down of the outer edges, but on some occasions, when they apparently took more pains with their handiwork, their movements during the preparation of the nest were exactly like those of the older females. Nests were often made during the day in pure fun, and many different materials, such as string, grass, branches, rags, ropes, and even wire, were collected for this purpose. It was quite evident that in their nest-making activities the younger chimpanzees imitated the actions of the older ones.

Clowning and Masquerade

Objects of many kinds interested these apes. They seemed particularly fond of carrying quite a variety of rubbish about on the body in one way or another. Nearly every day some of the animals began walking around the playground with a piece of rope, a bit of rag, a blade of grass, or a twig upon the shoulders. Some of them if given a bit of metal chain would put it proudly around their necks like a necklace. Bushes and brambles were often carried in considerable quantities spread out over the entire back. In these actions they affected a manner that revealed tendencies familiar to human masquerading in grotesque or fantastic costumes. One of the chimpanzees contracted the habit of carrying around empty preserve cans by grasping the lid of the can between his teeth. All of this occupation was done as diversion or entertainment, from which the chimpanzees derived much visible pleasure. The clowning actions of these apes clearly held the attention of those not actively participating in the performances, and many of them, like little children, attempted to imitate the antics of the leader. When dressed up in these various ways the chimpanzees often displayed an almost impish self-important audacity, strutting about among their companions or advancing upon them in a menacing way. One of the older females, attired for play, would trot around in a circle with several of the smaller animals following closely at her heels. Sometimes the entire company playing in this fashion would march around in a circle, one behind the other. The largest animal would stamp its foot at each step, as though beating time for the parade. The other animals followed suit by an accentuation of the marching movements.

Manufacture and Building

Not only did the chimpanzees acquire many ways for employing objects which they encountered, but some of them actually went one step farther. They manifested a degree of ingenuity in constructing special implements for themselves. The results of this constructive industry, it must be admitted, were relatively simple. On the other hand, there can be no doubt that the chimpanzee does manufacture instruments, in a modest way, which help him to gain his ends. One of the most talented apes learned to fit a small piece of bamboo into the cavity at the end of a larger piece. In this way he built a long bamboo pole, which was especially useful for procuring food hung above his head and out of reach. All of the chimpanzees ultimately developed some degree of constructive or engineering ability. They actually became builders on a small scale. This ability grew out of their learning to use boxes in order to reach objects over their heads. Using one box led to the advantage of piling one box on top of another and thus constructing a tower. They were not all equally expert as builders. As might be expected, the more quick-witted and alert members of the group learned how to build first, and this they did entirely of their own initiative. After they had built a tower of this kind, the long bamboo stick came in handy as a means to bring the suspended banana to the ground. Here two modes of solving a problem were combined—that of building, and that of using the long pole. Building operations soon became a favourite pastime; yet in spite of the fact that they were given every opportunity they never developed an efficient labour organization. However helpful united efforts may have been toward their ultimate aim, the chimpanzees failed to realize the advantages of a mutual aid society. There was doubtless a reason for their lack of intelligence in developing higher efficiency in this respect. Almost invariably their building operations were dictated by a desire to obtain food that was out of their reach. Among the chimpanzees this goal was in no sense a mutual interest. It was a matter of the utmost selfish concern to each chimpanzee. So whatever advantage there might have been in a division of labour, there was never a thought of dividing the spoils. When the chimpanzees gravely assembled in the presence of a basket of food hung up over their heads, they gazed about for proper materials to use as tools in reaching the desired goal. One would bring a pole; another would drag up a box. These were put in position preparatory to constructing a tower. The building would then begin in earnest. When the first stages of construction were complete several of the animals at the same time would show great impatience to clamber up. Each one of them acted as if either he or she were the sole proprietor of the structure. Often, too, the box already in position would be snatched away by some competitive group in the building industry and dragged off to be used in the construction of a rival tower. This would usually result in a wrangle among the architects. In fact, the entire company of builders might come to blows over this infringement of property rights. After the subsidence of these Babel-like controversies the building would be resumed and the structure would continue to grow in height until it became an object of ever-increasing excitement to the assembled workers, each manifesting a keen desire to mount it. In consequence of this highly individualistic competition and due to their restless efforts, the tower would sometimes tumble over and the result of their labours be destroyed. Then it was necessary to begin all over again. Usually in this renewed effort only the more diligent and patient of the chimpanzees adhered to the original purpose. The others became interested in more trivial occupations. Eventually the tower was finished, and the more diligent as well as the more patient of the toilers quietly mounted to the summit of the structure and, either with or without the aid of the pole, obtained the coveted bananas. Sometimes, however, just when the diligent one was ready to reap the just reward of his efforts, some member of the group endowed with unusual athletic prowess rushed up stealthily and with great speed to the top of the tower and seized the prize before the rightful winner had time to protest or retaliate. In all of this building enterprise there is something so fundamentally human, so reminiscent of modern methods, that it seems inaccurate to class these reactions too rigidly in the category of ape behaviour.

Emotions of the Chimpanzee

The chimpanzee, according to Professor Köhler, has a range of expression of emotion even greater than that of the average human being. The chimp shows his feelings by his entire body, not merely by his facial expressions. It is his custom to jump up and down both in joyful anticipation and in anger or annoyance. In extreme despair or disgust, which the animal shows on slight provocation, he has the habit of flinging himself upon his back, rolling wildly to and fro, swinging and waving his arms about his head in a frantic manner not, on the whole, very different from the way in which some non-European races manifest their disappointment and dejection. The chimpanzee is not known to weep, nor does he laugh in quite the human sense of the term. There is something approaching human laughter in his rhythmical gasping and grunting when he is tickled. While quietly watching objects that seem particularly pleasing (and his greatest delight comes from observing little children) the face of the chimpanzee, especially around the mouth, has an expression not unlike a human smile. When perplexed or in doubt, he has a way of scratching the surface of his body, especially the arms, breast, or upper portions of the thigh. It has not been stated that during these moments of perplexity he scratches the head, as is the common human custom. He conveys his meaning not only of emotional distaste but also of definite desires. The expression of his wishes is in large part shown by direct imitation of the actions desired. Thus, when one chimp wishes to be accompanied by another, he gives the latter a nudge and pulls him by the hand. If one chimpanzee wishes to receive bananas from another, he imitates the movement of snatching or grasping accompanied by pleading glances. The summoning of another chimpanzee from a considerable distance is often accompanied by a beckoning that is very human in character. Their many actions in all instances are characteristic enough to be understood by their comrades.

Surgical Interests

The chimpanzee is especially prone to pay close attention to the wounds or injuries received by his fellows. The motive of this attention may scarcely be called mutual aid. The removal of splinters from each other's hands and feet is a favourite clinical operation. In this pursuit the chimpanzee employs methods usually in vogue among the human laity. Two finger nails are pressed on either side of the splinter, which is thus elevated until it may be caught and removed by the teeth. Professor Köhler himself, once having suffered from such an accident, ventured to allow one of the chimpanzees to remove the splinter from his hand. On perceiving the condition, the chimpanzee's face at once assumed an expression of eager intensity, and his attention became concentrated in preparation for his surgical efforts. He seized the hand, examined the wound, forced out the splinter with two somewhat powerful squeezes of his finger nails, and then closely examined the hand to be satisfied that his work was well done.

Morals Among Chimpanzees

There is much of interest in the experiences of another distinguished observer, Dr. Charles F. Sonntag, formerly Prosector of the Zoölogical Society of London, who has called attention to the fact that the chimpanzee is said to be filthy in its habits. He observed that many of these animals in captivity do not manifest such traits, nor do they show any tendency toward immoral behaviour as has been claimed. It seems unfortunate even to imply that such a delinquency as immorality exists among chimpanzees or, for that matter, any of the lower mammals. But since the point has been raised, it may be well to recall that morals are of human making. They are designed to modify, to restrain, or to prevent the development of certain animal tendencies which are a human heritage from the great animal kingdom. If the chimpanzee in any of its actions tends to depart from the code of morality established by man in one part of the world or another, this can be no reproach to the ape, since man himself has not yet been completely successful in building up a system of restrictive laws to protect himself from the devastations of his own animal inheritance.

Professor Köhler, from his long studies of the chimpanzees, concluded that these apes manifest intelligent behaviour of a general kind familiar in human beings. Not all of their intelligent acts are similar to human acts, but by means of well-chosen tests the character of intelligent conduct can always be traced in the chimpanzee. These apes differ among themselves just as much as people do, in their mentality and intelligence. Some of them may be mentally deficient, just as there are mentally deficient human beings. One remark of Professor Köhler's is a keen social criticism with a wide application to life in general. He maintains that the tests designed for the chimpanzee serve two purposes: First, they determine the intelligence of the apes; and, second, they test the intelligence of the examiner. This is eminently true in all intellectual contacts between human beings. It is a fact that the chimpanzees stand out among all other animals in their form, in their actions, and in their understanding. In these respects they come much closer to the human standard than any other ape, with the possible exception of the gorilla. All of these observations agree well with the theory of evolution, and in particular with the close relations existing between the growth of intelligence and the development of the brain.

Many other chimpanzees have been studied from time to time. The conclusions drawn from them have been closely similar to those already cited. Romanes some years ago studied the trained chimpanzee, Sally, which was famous for her high degree of intelligence. Under training this animal acquired the ability to count. She could draw a number of straws to six or seven, and upon request would indicate with straws the exact number she had been instructed to show. This achievement, in combination with many other extraordinary performances, reveals certain striking likenesses to man, particularly as to the degree of the chimpanzee's power to learn.

The Chimpanzee's Social Traits

Others besides Professor Köhler are willing to give the chimpanzee credit for unusual good-fellowship. All admit that he is a most friendly creature. Often an affectionate attachment exists between him and his owner or keeper. He is never loath to indulge in his clowning performances to please and entertain his human friends. His actions on these occasions have doubtless been the models for the ludicrous mimicry of olden times now generally referred to as "aping." In many of the army encampments in Africa, monkeys and apes have been the much-prized pets of the officers. It was not uncommon to find among these pets the highly sociable chimpanzee. Frequently the officers manifested much zeal and interest in training their charges and felt a real pride in exhibiting them. Sometimes on gala occasions these simian pets occupied places at the table beside their owners. They partook in most approved style both of food and of drink. Not a few of them have shown a distinctly human characteristic in their strong liking for intoxicating liquors. The chimpanzee has always had a decided penchant in this direction. At mess dinners and on other occasions he not only manifested a keen liking for good wines but took his share with the rest. Often he, like his human companions, rose to hilarious heights. Often, too, it was necessary to lead him off to bed in such a deplorable condition that he would appear next morning with a shaky hand on his brow and that sad expression which plainly told the consequences of festive revelry. One of these chimpanzees had a particular fondness for afternoon tea and would join the officers' group at this time as a matter of course. His manners were altogether agreeable. He acquired all of the airs essential to such occasions even to certain banal chatterings.

In Prophecy of the Human Brain

If doubts should remain concerning the superior and almost manlike capacities of the chimpanzee, these may be soon put at rest by inspection of his brain. In this organ there are indications of the means by which the chimpanzee has acquired his new and extensive powers of learning, his greater understanding, his higher capacity for adjustments to life, and his many reactions which are so nearly human.

Every sense department in the superbrain has shown pronounced improvements. A survey of the chimpanzee's brain shows it to be a mechanism better organized for the purposes of efficient output than that of other apes and monkeys. It is a larger brain. It also has a greater richness in grooves and convolutions showing that its capacity for developing brain power has been much increased. The groove of Sylvius has been tipped backward in consequence of expansions in the department of hearing and the department of body and contact senses. In the department of hearing (the temporal lobe) the convolutions are more complex than in any other lower apes or monkeys. In fact, the entire pattern of coil arrangement in this part of the superbrain is similar to that seen in man. It has, perhaps, a simpler design, but the essential features of the pattern may all be identified. In the department of sight the same principle of expansion has been at work. The convolutions in the occipital lobe have increased both in number and complexity of arrangement. There are more grooves and more convolutions in this region than we have yet encountered. Such also is the case in the department for body and contact senses (the parietal lobe), in which the grooves and convolutions manifest an arrangement identical to that of man. The lesser brain, lying as it does tucked away beneath the occipital pole of the superbrain, also shows marked increase in size, so that the subsidiary department essential to postures of the limbs and body, and also to balance, has kept pace with the superbrain. Appraised on the value of its great working departments, a brain like this reveals the manner in which progressive development has advanced.

The organization for transacting the functions of hearing has been greatly improved, if we judge by the enlargement of the temporal lobe. Furthermore, it appears that certain sub-departments for handling these transactions have been established. They doubtless have to do with a better filing system for auditory impressions and especially for correlating the impressions of things heard with similar records of things seen. This method of cross reference produces a better understanding of all objects encountered in the surroundings. A practical illustration may assist in visualizing the manner in which such associations operate. If in their home life the chimpanzees are suddenly startled by the report of a gun, which they have never heard before, the entire family may be greatly perturbed by the harsh and unfamiliar sound. The sound alone might be startling and disagreeable, but the sound cross referenced by the sight of the hunter and gun comes to mean peril. Instances of this kind might be multiplied to show how essential to success in life this system of cross reference is. In fact, it is the amplification of this system that underlies our progress as individuals or as a race. The structural signs of this progress are to be found in the region of the brain that we have been discussing. We may recognize them in the increased number of convolutions which provide for better development of brain power. Equally pronounced are the advances that have taken place in the organization of body and contact senses. This department lies immediately above the Sylvian groove in the parietal lobe. It receives all communications transmitted from the outside world by the sense of touch and by the various movements of the body. The convolutions in this region indicate a highly organized department which we might expect in view of the remarkable performances of the chimpanzee. Walking a tight rope, eating his food with a certain degree of good manners, drilling to music, or driving an automobile, the chimpanzee clearly demonstrates how expert he has become in the use of his hands and feet. His cleverness depends upon his ability to sense the things he touches and to appreciate the finest grades of motion made by his arms and legs. In addition to this high degree of sensing in his hands, he has also acquired greater capacity for appreciating movements and postures of his entire body. Unless the chimpanzee had this expanded department for body and touch senses, it would be impossible for him to learn many of the performances which he does so skillfully. He also would be unable to apply this skill under the direction of his masters or according to the dictates of his own wishes. It is not difficult to understand, therefore, why all the great departments of the senses have increased so much in size in the chimpanzee. Obviously, by amplifying and refining the raw materials received as sense impressions, the output seen in the chimpanzee's behaviour has been correspondingly amplified and extended. The significance of growth in the parietal, the occipital, and the temporal lobes in this light becomes clear.

One important detail in the superbrain of the chimpanzee we have not yet considered. It will be recalled that the central groove is one of the salient landmarks in the brain. Its outstanding importance arises from the fact that it is the boundary line of the frontal lobe. All of the territory lying in front of this groove represents the last acquired department of the super-brain, the one having the highest authority. It is here that all of the highest brain functions are located. Judgment and reason are included in this list. But to these should be added the ability to profit by experience in the better guidance of life, the upbuilding of personality, and the proper adjustment in all courses of action requiring initiative, insight, restraint, and self-control; and, finally, recognition of responsibility and appreciation of opportunity.

The frontal territory in the chimpanzee is more extensive than in the orang or any other of the lower apes. It shows an additional amount of convolution. The frontal coils for producing the brain power of this highest department have attained a development not far below that of man. The counterpart of each human convolution is present, the only difference being that each individual convolution in the chimpanzee is less complex than in man. These facts about the frontal lobe, which we must regard as the permanent headquarters of the chief executive of the super-brain, are in harmony with what Professor Köhler and other students of animal psychology have told us about the chimpanzee's intelligence. Man's frontal lobe is a highly complex facsimile of the chimpanzee's, just as human intelligence is a more complex development of the higher mental powers.

These improvements in the superbrain are borne out by both the bridge and the pyramid. The bridge, recognized as a reliable index of intelligence, has the value of .400 in the chimpanzee, a rating much above the orang or any of the lower apes already considered. The pyramid also shows a corresponding increase, having a value of .172, and thus indicating a greater development in skilled acts and in the voluntary control over the actions of the body. These two structures show that the superbrain has, in fact, become a more efficient governor for the guidance of a larger, a more complex, and a more effective machine. Every detail in the brain of chimpanzee clearly demonstrates the marked advance that has been made in the steady upward climb. We are able to identify all of the chief features characteristic of the human brain.

CHAPTER X

ALMOST HUMAN

THE BRAIN OF THE GORILLA

The largest member of the ape world is the gorilla. There is much dispute to-day concerning the place he occupies in relation to man, and also as to what rating his intelligence deserves. Neither of these questions can be settled at present. His case, in fact, requires much more study than has yet been given to it. Recently the gorilla has been befriended by several famous African explorers like the Bradleys and the late Mr. Carl Akeley. They have given him a rather favourable recommendation as an inoffensive and retiring animal. In spite of this vindication, however, most persons who have any acquaintance with him regard the gorilla as a dangerous, savage brute. Standing upright, he is nearly as tall as the average man. Sometimes his height reaches six feet, and often the adult male attains the great weight of nearly four hundred pounds.

A Superlative Fighting Machine

The body of the gorilla is stout and large. His legs are short but his arms are extremely long. When standing erect the tips of his fingers reach to about the middle of the leg below the knee. His huge and grizzly head, flat, broad nose, prominent muzzle, large mouth, very large canine teeth, and protruding ears all give the animal a terrifying appearance.

The manner in which he rises on his hind legs and makes the forest reverberate with his roars when attacked is one reason why the gorilla is considered the most savage of all beasts. His hands are large and thickly covered with black hair on the back. The palms of the hands have no hair. They possess many grooves and markings with strong human resemblances. The thumb is somewhat short for the size of the hand, but is thick and bears a broad nail. The animal's body as well as the head up to the brow line is covered with thick, black, shaggy hair. The skull is massive and heavy. The eyes are surmounted by a heavy ridge of bone, and a thick bony crest extends from the bridge of the nose to the back of the skull along the middle of the head. All of these bony structures provide the gorilla with a most effective fighting helmet. The massive head, the short neck, the powerful arms, and the savage teeth create the impression of a superlative fighting machine—a sort of dreadnaught. But this machine has one inherent weakness. The feet and legs are inadequate for a finished fighter. The gorilla is able to assume the upright position and walks thus in an awkward manner, using the arms in balancing. In the main, however, he goes on all fours, especially when making speed through the underbrush or climbing among the trees. He rises upon his hind legs largely for purposes of inspection in order to make a survey of the surrounding territory.

Many species have been identified. They all live in Africa. One variety inhabits the Gaboon in West Africa. It also extends into regions of southern and northern Cameroon, near the border of the French Congo. This variety of gorilla is especially adapted for forest life. Another type, sometimes spoken of as the mountain gorilla, inhabits mountainous localities in the Belgian Congo.

The Gorilla's Ancient Disrepute

The gorilla has been long and unfavourably known to mankind. Ancient rumour of him spread abroad many unsavoury reports about his savage disposition. In the Fifth Century B. C. gorillas were first spoken of as wild, hairy men living in Africa. The Carthaginian Admiral Hanno, in his famous voyage to the Pillars of Hercules, appears to have been the first white man to encounter them. He and his comrades unexpectedly came upon a group of these wild people. All of the men fought so savagely that they made their escape, but Hanno and his friends were able to capture three of the women. These females were so ferocious and unfriendly that it was necessary to kill them. Their skins were preserved, taken to Carthage, and there placed in the Temple of Juno, where they were held sacred until that city was destroyed.

The famous explorer, Paul Du Chaillu, in his *Explorations and Adventures in Equatorial Africa* describes the gorilla as gregarious. He found them going about in companies of eight or ten. Sometimes the older males become superannuated. Then they live solitary lives apart from these small communities. When grown old they appear actually grizzled with age, and the hair, which in youth is black, becomes almost white. Du Chaillu was probably the first European to kill a gorilla in its native forest. His description of their habits was thought to be an exaggeration, but later information largely upholds his opinion. He believed that the gorilla did not, as often claimed, lurk in the trees just above the roadside in order to reach down with his great arms and snatch up the unsuspecting passer-by. He discredited the ancient story that these animals attack elephants and beat them to death with sticks, and that they carry off native women to devour them in the depths of the forest. He did not even believe that the gorilla built itself houses or nests from twigs among the trees, or that large bands of them made attacks upon men whose homes were in the neighbourhood of the forest. Du Chaillu reported that the gorilla lives in the loneliest portions of the dense African jungle. It is seldom found in the same place two days in succession. It prefers deep wooded valleys or rugged heights and roams about over a large area in search of food. It consumes a large amount of food, such as pineapple leaves, berries, wild sugar cane, and other vegetable matter. The animal sleeps sitting on the ground with its back against the trunk of a tree, and when full-grown seldom ascends high among the branches. The young sleep in the trees, and possibly the females may occasionally do so.

Like Some Monster of a Nightmare

In spite of their reputation to the contrary, the gorillas are in reality shy. The female will run to shelter at the first sound of alarm, carrying her young one with her. The male, however, is less hurried in his retreat. In fact, he seems to act upon the theory that the best defense is an attack. He rises up on his hind legs for a moment, showing his savage face among the underbrush. Then, glaring at the intruder, he begins to beat his chest with his closed fists, at the same time uttering a deep, terrifying roar. This sound begins at first as several loud barks like those of a dog and then changes to a deep-throated growl, which is emitted with redoubled force, causing echoes in the forest like distant thunder. Du Chaillu said that the horror of the animal's appearance at this time is beyond description. It seems like some monster of a nightmare, an indescribable piece of hideousness.

In walking, the gorilla waddles from side to side as he proceeds upon his hind legs. Meanwhile, in order to balance himself, he swings his great arms at his sides, which makes him appear more determined and awe-inspiring. When attacking, his features are distorted by hideous wrinkles, and his lips are drawn back revealing long fangs in the powerful jaws by which a human limb could easily be crushed.

The celebrated African explorer, Mr. Akeley, has pointed out that there is no difficulty in shooting the gorilla. In fact, against modern firearms this animal is as defenseless as a crippled woman. Such hunting is thoroughly distasteful and seems to be an atrocity closely akin to murder. It was due to Mr. Akeley's efforts that the King of Belgium recently set aside a large territory in the Congo as a gorilla sanctuary, in which all hunting of this animal is prohibited. Here, in the vicinity of the three extinct volcanoes, Mt. Keno, Mt. Karissimbi, and Mt. Visake, Mr. Akeley hoped that a biological station might be established for the further study of the gorilla's behaviour. In this sanctuary, now known as Albert National Park, he believed it would be possible to gain a footing on close and intimate terms with this gigantic ape. Mr. Akeley was convinced that the gorilla's reputation for ferocity was greatly exaggerated, and that the animal was actually a timid and retiring beast. This new estimate of the gorilla's disposition gives encouragement to the expectation that in time this fast-disappearing offshoot of the prehuman stock may furnish its full testimony concerning the evolutionary process.

Training the Young Gorilla

In adult life the gorilla is untamable. If captured young, as much may be done with it as with many other apes in captivity. The following account of a gorilla's life in civilization, given by Miss Alyse Cunningham, of London, testifies to this fact. It is the story of the young gorilla called "John Daniel the First." The record was made by Miss Cunningham herself. At first she had no fancy for this animal; in fact, she felt rather a dislike for anything in the shape of a monkey or an ape, but she soon became interested in the young gorilla and took his education seriously in hand. The animal was presented to her by her nephew, Major Penny, shortly after the end of the Great War. He was much interested in apes and bought the gorilla with the idea of seeing how much mentality it possessed and how much it could be developed. John Daniel was captured when very young in the French Gaboon country and came to England when he was about three years of age. Major Penny first saw the young gorilla on exhibition, during the Christmas holidays, in a large show window of a well-known shop in London. The animal attracted much attention and large crowds gathered daily to watch him. As a dry-goods advertisement he was a splendid investment, but unfortunately at that time he was suffering from rickets. With the severe changes of weather in the Christmas season he contracted an attack of influenza. On this account his owners were compelled to retire him from his advertising post and found themselves at their wit's end to know what to do with this sick infant gorilla. When he was finally sold to Major Penny his original owners did not think he would survive for very long. In this respect their calculations went astray. Miss Cunningham took the sickly gorilla, nursed him as she would a child, brought him through his influenza, and so successfully cared for him that during the next three years he reached the weight of 112 pounds and the height of three feet four and a half inches. Meanwhile, he acquired many of the habits and adjustments necessary to fit him as an interesting if somewhat unusual member of the household.

John Daniel the First

We are indebted to Miss Cunningham for the excellent account of his life, which indicates the extent to which this great ape may be trained and educated. Little John, immediately after his recovery from influenza, began to show some singularly childlike emotions. He was gentle and affectionate in response to the tender care he received. But he became too much attached to his new and kind friends. His devotion in this respect created some difficult situations in the household. If he were left by himself at night he would shriek from fear and loneliness. Perhaps he remembered the long and cheerless nights when he was a Christmas exhibit in the department store. In any event, Miss Cunningham was forced to treat him just as she would any little child. She coaxed and soothed and petted him until she had allayed his fears. Then he would become quiet and fall asleep. But even this was not sufficient. It soon became necessary to place her nephew's bed in the room adjoining the cage of the gorilla. Apparently he craved companionship of some kind and at length became quite happy under this new arrangement.

John soon began to grow and to put on weight. He gradually got over his rickets. At first he was taught to be clean in his habits by a system of rewards and punishments. At the end of six weeks he was thoroughly housebroken. At this time he was taken out of his cage and allowed the freedom of the house. Thereafter, John would always run upstairs to the bathroom of his own accord. He would turn the knob of a door and took pains to see that he always left it closed behind him. He showed strong likes and dislikes in the matter of food. There was one feature that always puzzled Miss Cunningham in this respect. Generally speaking, John was not a thief. He manifested average honesty, but when it came to food he much preferred to steal it than have it given to him. It was difficult to understand the motive underlying this course of action. There were some things about it that seemed to indicate a real satisfaction derived from stealing, due, perhaps, to an outcropping of his native cunning. Perhaps it was the consequence of a well-recognized quality of natural aloofness characteristic of the gorilla in general that made John Daniel averse to receiving favours from others. He would always avoid any food that had been exposed to the air for long. He was particularly fond of oranges and apples, but would never eat them if they had been cut a few hours. John had what almost amounted to a passion for eating roses. The more beautiful they were, the more he seemed to like them, but nothing would induce him to eat faded roses. Nuts he did not much care for, although at times he showed a liking for walnuts. A cocoanut was always a problem to him. It was most amusing to see how he went about this problem. He understood that it was necessary to break the cocoanut. First he would throw it upon the floor, but failing to break it this way he would finally bring it to one of the members of the family with an appealing look for help. If given a hammer he would use it viciously on the nut, but never effectively. After several failures John would take the nut and the hammer to someone, indicating what he wanted.

John's Social Behaviour

John had a good understanding of tools, almost too good, in fact. In consequence, hammers, chisels, and saws were kept in hiding, and if John happened to find them he was apt to indulge in a somewhat ruthless carpentry on the household furniture. From his babyhood, and while he was growing up, he was always fond of people. He liked to have them come to visit him at his home. Far from being timid and shy, he was quite the reverse. Whenever there were visitors he always liked to show off, just like a child. He would take the visitor by the hand and lead him round and round the room. This amused John greatly, and if his guest responded playfully all went well, but if there was any sign of nervousness or fear John took an impish delight and would run by the visitor, giving him a smack on the leg. Then, perching himself on a chair, he would grin foolishly at his own mischief. This was the only blemish on his company manners, and he always appeared a bit shamefaced when rebuked for such misbehaviour. He did not, however, go the length of making apologetic overtures to his offended visitor, but kept himself aloof with an air of injured innocence.

Miss Cunningham had few misgivings about John when she had company in the home. He was always very obedient to her and seemed to recognize that her wishes were law. It hurt him apparently to be guilty of any act which caused her displeasure, and while sometimes he would perpetrate some mischief on the sly he would always be on his best behaviour when he felt Miss Cunningham's eye upon him. His table manners were rather good. He always sat at the table, and when the meal was ready would pull up his chair to the designated place. He never cared for great quantities of food, and his actions at table required little, if any, more reproval than did an ordinary child. He was especially fond of drinking water from a tumbler. He always took afternoon tea with the family. He had a particular liking for this beverage and with it would eat a thin slice of bread with plenty of jam. He also liked his demi-tasse of coffee after dinner. The family estimate of him was generally high. He was regarded as the least greedy of all the animals that had ever come under the observation of his owners. He would never snatch for anything at the table, and he always ate slowly. He was accustomed to drink large quantities of water, which he got for himself whenever he wanted it by turning on the tap. Strangely enough, he always turned off the water when he had finished drinking.

A Gorilla with a Sense of Humour

John Daniel had a very good opinion of himself. He was quite well poised and self-contained. Nothing seemed to ruffle him, and he could amuse himself in simple ways by the hour. He seemed to believe that his own estimate of himself was shared by others and appeared confident that everyone was delighted to see him. Often he would stand on the window sill and throw up the shade. In a short time a large crowd would collect on the street below to watch this unusual sight at the window. He enjoyed such publicity immensely and would stand watching the people for a long time. Once in a while, if the crowd grew very large, he would pull the shade down deliberately in their faces and run away shrieking with laughter, in a way which seemed to indicate that he was conscious of having perpetrated a huge joke upon his audience outside. Of course, this entire reaction and the motives underlying it are open to several interpretations. Skeptics will say that the version here given endows the gorilla with attributes more human than he could possibly possess. However that may be, those who actually observed these performances were impressed by the fact that John Daniel did act in a seemingly human manner.

Fondness for Little Children

John was especially attached to Miss Cunningham's three-year-old niece, who often came with her mother to stay at the house. They would play together by the hour. The gorilla seemed to know just what this little girl wanted him to do. If she cried for any reason, when her mother came to pick her up, John would give the mother's hand a nip with his teeth or slap her with the full weight of his palm, apparently thinking that she was the cause of the child's grief. One day Miss Cunningham was dressed for going out, and John Daniel wished to sit on her lap to bid her good-bye. It chanced that her gown was a light-coloured one, and she pushed him away, saying that she feared he might soil her dress. Poor John was deeply distressed. At once he lay down on the floor and cried like a baby for a moment. Then he looked around the room, found a newspaper, laid it on Miss Cunningham's lap, and climbed up on it. This was the cleverest thing he had ever done. Those who saw it said they would not have believed it had they not themselves been present.

Like a Child in Play

John Daniel apparently could stand a good deal of cold weather. He would often climb out on the roof when the thermometer was below the freezing point. He did not seem to mind how cold it was so long as he could come back into a warm room when he wanted to. Then he would go directly to the fire, rub his chest, and sit down with his feet cocked up on the fender. Exercise was necessary to keep him in good health, and John got much of this by playing hide-and-seek with Major Penny. In the morning before breakfast and in the evening before dinner the Major would run up and down stairs, in and out of all the rooms. The game appeared to delight the gorilla, who would giggle and laugh while being chased. He never took any chances about going into a dark room, however. Invariably he would make sure to turn on the light first.

It was his habit to retire each night at eight o'clock, and it was not necessary to tell him to do so more than once. He had his own little room adjoining that of Miss Cunningham's nephew, in which he had a spring bed of his own, with blankets and pillows. At night he would get up out of bed by himself, go back to bed, and pull the blankets up over himself quite neatly. One of John's greatest pleasures was to stand on the top rail at the foot of the bed and jump on the springs, just like a little child. He was never taught any tricks, but simply acquired knowledge by himself. In the summer time John was taken by train to the family's cottage in the country. He occupied his seat in the railway coach like any other passenger, without so much as a chain around his neck. When out of doors the broad fields and open country seemed to terrify him, but he was singularly happy and contented in the quiet garden or in the woods. He seemed to fear full-grown sheep, cows, and horses, but colts, calves, and lambs attracted and amused him. It seemed to those who cared for him that he recognized youth and was sympathetically drawn to it.

John Becomes Famous

As the years passed he became more devotedly attached to the family. If left alone he would make a great noise, shrieking and crying. This tendency increased, so that after three years it was necessary to make some other arrangement for him. Through a misunderstanding which his owners have always regretted, John was sold to a circus. He was taken across the Atlantic to New York. Here, after a month's separation from his devoted friends during which time he refused to take food and showed every sign of real homesickness, he died in the tower of the old Madison Square Garden, in April, 1921.

Many of the New York daily papers published a notice of this remarkable ape's death, telling how the gorilla, John Daniel, homesick and disconsolate without those who had befriended him, died of a broken heart. The skeleton and taxidermic preparation of this gorilla, who has contributed so much to our knowledge and understanding of the great apes, may be seen in the anthropoid collection in the American Museum of Natural History, bearing the label "John Daniel."

A Gorilla at Afternoon Tea

As an interesting sequel to this history of what appears to be the first gorilla raised under the conditions of such intimate domestic life, it may be added that Miss Cunningham secured another gorilla, which she called "John Daniel the Second." John Daniel the First was a little over six years old when he died and was then less than half grown. These two great apes resembled each other closely in their emotional reactions and in their responses to training. Both were about of the same age. John the Second was perhaps a less likable individual and had a disposition more in keeping with the ancient reputation of gorillas. Several years ago, while he was visiting in New York, a number of scientists were invited to have afternoon tea with him at a certain fashionable hotel. On this occasion the troglodyte host was found seated in a comfortable chair. He displayed much gravity and apparent enjoyment as he drank from a cup of tea. During the course of conversation John the Second was for a moment not the actual centre of attention. Suddenly he dashed across the room with unbelievable swiftness and attacked one of his visitors with repeated rapid blows of both fists in the neighbourhood of the solar plexus. Just as quickly he hopped over the foot of the bed and from this point of vantage watched the discomfiture of his guest. A moment later, when less sharply watched, he hurled his full weight in most approved football style against a distinguished professor of zoölogy, who, as a result, was thrown from his chair. In the intervals between these presumably playful diversions this powerful gorilla sat quietly. Yet, in spite of his innocent demeanour, one was suspicious that he was casting about for the next piece of mischief that he might perpetrate. There was a degree of roughness and sudden strength in the playfulness of this young gorilla that afforded some idea of the terrific power these animals must possess when full grown.

The attractive prospect of a biological station in Africa, as suggested by the late Carl E. Akeley, for the study of the gorilla is inspiring. It should be possible under these circumstances for one scientifically inclined to saunter into the jungle of a morning, call to some particularly promising gorilla, and with the troglodyte spend many profitable hours in biological study. If the full-grown gorilla, however, is anything like John Daniel the Second, this studious occupation might not prove so simple. Indeed, it seems probable that only the most hardy of human adventurers will ever enjoy the privileges of anything approaching a familiar acquaintance with these giant apes. Such adventurers may live to report that the great brutes have acquired no marked degree of gentleness even in their own gorilla sanctuary.

The Art of Capturing Young Gorillas

On a number of occasions young gorillas have been captured alive. Mr. Ben Burbridge, using some clever tactics, has succeeded in capturing several small gorillas. The approved style of such hunting is to lure the young animal away from the older gorillas; then, grasping the throat, force it to the ground until helpers arrive to slip a stout bag over its head. On one occasion Mr. Burbridge succeeded in artfully luring a gorilla from the rest of his family. He at once proceeded to seize him in the usual manner. Immediately he realized that he had caught a tartar. The young gorilla was much stronger than any man, and grasping both of Mr. Burbridge's hands he forced them into his savage mouth. Nothing but iron nerve and quickness of wit would have saved a man under these circumstances. Realizing his inability to overpower the gorilla or free himself from its vise-like grip, Mr. Burbridge did the only thing left for him to do. He thrust his hands down the animal's throat as far as they would go. Several natives finally succeeded in overpowering and binding the young giant. The first burlap bag put over his head he split asunder like a piece of gauze. At length he was bound and carried off to camp. But this young monarch of the volcanic mountain sides would not accept captivity. He was unapproachable and so actively hostile that he soon died. Later, Mr. Burbridge succeeded in capturing and bringing home to Florida a small female gorilla, weighing sixty-five pounds, which he called "Congo the Second."

Professor Yerkes Studies "Congo the Second"

We are extremely fortunate that this gorilla has been studied by Professor Yerkes, who in a book recently published, called *The Mind of a Gorilla*, has given us another of his brilliant works on animal behaviour. This is a most readable account of Congo's actions, and those who wish further information will derive much pleasure from Professor Yerkes's story. All of his observations are illuminating and helpful in understanding the brain of this great troglodyte.

The mountain gorilla, as Professor Yerkes points out, is built for strength rather than speed. Congo, although still in her childhood, and weighing only sixty-five pounds, was amazingly strong. She could lift weights and overcome resistances that required the full strength of a grown man. In her play with a young Airedale terrier she became so rough that the dog finally avoided her. Her climbing among the trees, about which she seemed eager, was scarcely any better than that of an active small boy. It was easy to outrun her and throw her off her balance. The tremendous strength of the gorilla must, therefore, be looked upon as the real secret of his success in life. Without this strength he probably would not have survived, since he has neither the skill in climbing nor the speed upon the ground to escape his deadly enemies. His deadliest foe is the leopard. This stealthy and powerful cat often steals up to a gorilla family and snatches away the little ones. The gorilla's sole defense against the leopard is his gigantic strength. If at present this great ape is threatened with extinction it is because his natural enemies are increasing in number. Man with his modern equipments must be listed among these hostile contemporaries. For ages the struggle between the gorilla and his enemies in the jungle has been going on relentlessly. The great ape has been able to maintain that margin of superiority which permitted his kind to come down into modern times.

Professor Yerkes devised a series of tests for determining the mental capacity of the young gorilla, Congo the Second. These were arranged in several groups such as the following:

1. The use of the stick as an implement.
2. The use of simple mechanisms showing adaptive ability.
3. The uses of boxes and piling boxes.
4. Tests for memory.

5. Observations of social relations.
6. Study of emotions and incentives to action.

The Mind of a Gorilla

In all, twenty-four tests were employed in the experiments to fathom Congo's mind. Among them were the stick used as an implement, a buried jar of food, food suspended and made accessible by using the stick, food suspended and made accessible by piling boxes one on top of another, the use of hammer and nail in imitation of a man using the same implements, the mirror test and the animal's reaction to the looking-glass. Professor Yerkes carried on his studies through a number of weeks on two different occasions. The first series was conducted in January, 1926, and the second series, largely repeating the conditions of the first, in January, 1927. During this time the little gorilla had grown and prospered. She had doubled her weight in twelve months and she manifested many changes in her behaviour. In the first place, she had become somewhat destructive, although when she first came to Shady Nook in Florida this was not the case. Her curiosity had increased as had also her powers of imitation and her emotional expressions. She was much more self-reliant and likewise more coöperative. She showed a very considerable improvement in her ability to solve the problems of the several tests given to her. In using the stick she manifested greater cleverness and adaptability, with some indications of real insight into the situations that confronted her. There were signs also that she had gained a greater degree of adaptability in the use of simple mechanisms. These appliances in her earlier tests baffled Congo, but upon repetition a year later she not only gave evidence of memory concerning the tests but also had more ability in solving the problems which she had previously failed to master. She showed much improvement, particularly in piling boxes one upon another. Certain memory tests, which were unsuccessful in January, 1926, were quite successfully performed in January, 1927. Heretofore, no animal except man has been capable of correct response in these particular memory tests. Congo's success possibly demonstrates the existence of a mechanism in the gorilla brain that is possessed by the most highly organized animals only. It is this mechanism, doubtless, which distinguishes man and the great apes from all other mammals. Buried food tests also demonstrated an ability to remember after intervals of one or two days. Congo's emotions likewise had changed. At first she appeared aloof, independent, and inexpressive. She still remained reserved, and although playful she was highly self-controlled. Her emotional expression by voice, face, and attitude was rare, and seldom appeared in response to definite provocation. Her incentives and motives seemed much more complex than in lower animals, like rats and guinea pigs. Congo was moody, having her good days and bad days in doing the tests. The inducements offered her to perform certain acts did not have the same certainty that they have with lower animals. In her social relations she was extremely simple. She apparently gained an increased interest in those with whom she was familiar and also with strangers. She enjoyed visitors and acted in a limited way to entertain them. Seeing herself in the looking-glass, she had a marked interest in her image. In the second series of tests her interest in the mirror seemed more intelligent than the first. In sexual interest Congo showed a marked development. At first she manifested nothing resembling sex play, but in the course of the year this became evident in her relations with her dog companions and other objects. Ultimately she had a decided preference for the male dog.

Mental Comparisons of the Great Manlike Apes

Professor Yerkes's comparison of the behaviour of the three great apes, the orang, the chimpanzee, and the gorilla, is particularly interesting and important. He carefully guards his statement by acknowledging that these are rough comparisons based on the intimate study of only a few individual apes. The physical differences between these anthropoids may have a definite bearing upon their mental characters. The chimpanzee is well but lightly built. The orang, in contrast, is loosely built, with arms that seem much too long and liable to be in the way. The gorilla is stocky, somewhat clumsy, but of impressively strong build. The general disposition of these three apes varies somewhat according to their physiques. The chimpanzee is sanguine, buoyant, alert, and snappy. The orang-outang is melancholy and taciturn. The gorilla is reserved and aloof almost to the point of manifesting a superiority complex. In their attitude toward others and things in general this same difference is observed. The chimpanzee is preëminently a leader in playfulness and invention of ways to amuse himself. He is quick, impulsive, energetic, and comical. He has much enthusiasm and optimism, all of which makes him the showman's prize. The orang is more slow and cautious, with little impulsiveness and no show of optimism. He seems more stable and dependable than the chimpanzee. He is certainly more readily depressed and discouraged than his livelier cousin. The gorilla is calm, reserved, cool, and calculating. His disposition is quite the opposite of that of the chimpanzee. The terms sullen, morose, ferocious, and unrelenting did not, however, apply to Congo, who was placid, self-dependent, and usually superior to the incidents of her artificial life in captivity. In curiosity the chimpanzee heads the list. The orang is a close second. The gorilla may be stirred to curiosity, but under such circumstances usually acts as though he considered himself superior to such childish indulgence. The manner and methods of learning in these three great apes are remarkably interesting. In learning by imitation from man, the chimpanzee has a long lead. The orang is not entirely unsuccessful in this matter, but the gorilla, especially as typified by Congo, shows an actual resistance to learning by imitation of man. The ability to acquire new habits and adjustments to life by means of trial and error shows that the great apes rank as follows: Chimpanzee first, orang second, gorilla third. Learning by ideas, experience, insight, and understanding seems to reverse this order and puts the gorilla at the head of the list.

Professor Yerkes appears to think that, as compared with chimpanzees and orangs of like age, Congo was remarkably slow in adapting herself and was more limited in initiative, originality, and insight. He concludes that the general tendency to rate the gorilla in a mentally higher class than the chimpanzee or orang finds no support from his study of Congo. He also believes that conclusions based on a single specimen of this great ape are not sufficient to determine the mental rating of the gorilla. This animal, like the chimpanzee and the orang, indeed like man himself, has great individual variations in mental development.

Such records as those of John Daniel, First and Second, made by observers little trained in the technical methods of behavioural study, must of course be accepted with some reservations. Viewed in the light of Professor Yerkes's studies on Congo, they do afford an illuminating picture of the gorilla's mental capacity, disposition, and ability to learn. To say the least, in all of these qualifications the largest of the great apes is strikingly human. Its brain, which weighs and measures more than that of other apes, is in many respects nearer to the brain of man. In the gorilla's brain it is possible to discern the process by which the progressive development of this organ has made great strides. All of the landmarks of the superbrain are more distinctly human in their arrangement and disposition than in the chimpanzee or orang. If the chimpanzee's brain is a human miniature, the resemblance to man in gorilla has become still more striking. The position of the Sylvian groove and of the ape groove marks the boundary of the two great departments of sight and hearing. In the gorilla both of these have increased the area for radiating brain power. The convolutions in both of these regions bear a close resemblance to those of the human brain. This similarity is likewise true in the department for body and contact sense, where the convolutions have increased in complexity as well as in relative size. The central groove forms the boundary for a well-defined frontal lobe. If it were possible to make a measurable contrast of this permanent headquarters for the higher faculties in gorilla to that of chimpanzee, it seems fair to say that the gorilla would show some slight advantage. This advantage may account for the gorilla's greater reserve, which in some ways indicates a more mature attitude toward life, especially when compared to the restless and more childlike behaviour of the chimpanzee.

Secret of the Gorilla's Survival

Professor Yerkes would perhaps be unwilling on the strength of his studies to admit any measurable degree of superiority on the part of the gorilla's mentality over the chimpanzee. Unquestionably this is a proper point of view in the light of those great apes which have been available for experiment and investigation. In the main, such gorillas have been both too young and too few in number to permit any just estimate of their real ability. One fact in their history does speak forcibly in behalf of their mental superiority over all other apes. In form and physique the gorilla occupies an intermediate position. He is not well adapted for great successes living upon the ground. He is too heavy to capitalize the full advantages of living in the trees. Added to this is the fact that he is both slow and clumsy. His one physical asset in the struggle for life is his gigantic strength. By means of this advantage he has been able to meet all comers of the wild, to contend with such deadly enemies as the leopards and other members of the great cat family. He has eked out an existence in a territory filled with all manner of hazards. Yet in spite of his handicaps he has not only held his place in nature but he has kept his line a vital and going concern with all the increasing odds against him. This success in adjustment must depend upon something more than mere chance. We are perhaps fair in assuming that added to his chief asset of brute-like strength there have been certain superior mental qualities derived from a superbrain and particularly from a frontal lobe which surpassed that of all his animal competitors.

The index of his powers to adjust himself to a strenuous life is shown by his bridge (*pons*). This gives him a rating of .480, which is still higher than in the case of the chimpanzee. Most interesting in this connection is the fact that the pyramid in the gorilla is .161, which is considerably less than in the chimpanzee. The pyramid, as will be recalled, indicates the degree of skill that an animal has in controlling its voluntary movements; that is, in making its muscles act in many and varied ways according to the dictates of the will. That the agile, speedy, and acrobatic chimpanzee should surpass the clumsy and slow-moving gorilla in this particular might be expected. In almost every other detail of its development the brain of the gorilla is nearer to man than is the brain of any other ape, great or small. Those who have studied this question are fully convinced of the near approach in brain structure which all three of the great manlike apes make to the human brain. If any final estimation is justified at the present time, the gorilla's brain appears to be the most advanced of all the apes and is, in fact, almost human.

CHAPTER XI

HUMAN AT LAST

THE BRAIN OF PREHISTORIC MAN

THOSE individual characteristics which distinguish the orang, chimpanzee, and gorilla may be easily recognized. Yet, notwithstanding their striking differences, these animals all belong to the same family, called the *Simiidæ*. As a family this was and still remains the highest in the ape world. All of the great apes manifest certain pronounced manlike tendencies. Up to this point they were progressive, but beyond it they did not go. They were not equipped to reach the upper footholds or to gain the vast plateaus on the top of the world. This last achievement remained for another, who, being freed from many simian restrictions, had already outstripped the anthropoids.

Human Superiority

As a machine, this newcomer in the animal world was more effective than any of his forerunners. His human superiority was not due to higher speed, greater strength, or better staying powers. Many of his animal competitors could far outdistance him, could easily overpower him, could surpass him in endurance. He did, however, have an exceptional advantage. He was able to combine these essential qualities with many others in a variety of ways and thus gain an ultimate supremacy. In the end it was better brain power that raised man above his lower contemporaries and set him on his path toward human success. This new power of his did not come all at once. It needed the steady effort of ages to reach its present development. Compared with the existence of other species, the human race is relatively young. In point of geologic time so also is the human brain. Many students are agreed that temporally and in other respects our brain has scarcely outgrown its childhood. The brain power of to-day may require further ages of development to attain its highest possibilities.

When man first appeared on earth he had much in common with the great apes. Although not descended from them, he had inherited with them many qualities from a common ancestor. It is now settled beyond question that in earliest times the human brain possessed all of the basic patterns and mechanisms still to be found in the gorilla, the chimpanzee, and the orang. It had one fundamental advantage that greatly improved its capacity for developing its power. Expansion was the secret of this advantage. It was apparent in all parts of the super-brain, but most prominent in the department of the highest mental faculties, the frontal lobe. We may discern this great advance at a glance by comparing the sloping, narrow foreheads of the great apes with the high and prominent brow of man. The frontal lobe gradually pushed forward over the eyes, and in consequence the forehead slowly rose above them. It seems fair to say that as the brow grew higher through successive stages the race gradually rose in humanity. We are still much in the dark concerning the early phases of this slow rise to power. Some of the stages, it is probable, we shall never know. On the other hand, a large number of human fossils have been found during the past century. From these it is possible to decipher what the human brain must have been like at certain critical periods of man's long journey. The brain, like all other soft parts of the body, disappears in time after death. How is it possible, therefore, to speak about the brains of men long since dead, or of races long ago extinct?

The Fossil Records of Man

It is true that only the bones of ancient peoples remain to tell us what they were like. Many of these bones have become fossilized by impregnation with minerals and are, so to speak, turned into stone. Thus they make an enduring record of man's bony framework. From these petrified bones we can read many things about the people of the past to whom they belonged. We can measure their height, determine the manner in which they held their bodies in walking, and estimate their muscular strength. We may even rebuild their bodies about their skeletons by using certain standard measurements and so gain a fair idea of what these men must have looked like when alive. From the shape of the head it is possible to decide whether the jaw was massive and protruding, or of modern type; whether the cheek bones were heavy and prominent or relatively inconspicuous; whether the forehead was low and receding or high and broad; whether the nose was flattened or had a high nasal bridge; whether the chin was weakly developed or large and firm; whether the brain case was small, round, and narrow, or long, high vaulted, and capacious.

Brain Casts of Extinct Races of Men

Many other characters of extinct races may be determined by means of exact measurement. So much has already been accomplished in this way that it is possible to reproduce a reasonable facsimile of races that vanished long ago. It is possible also to reproduce a reasonable likeness of their brains. Reproductions of this kind depend upon the use of the fossil skulls as molds from which plaster of Paris casts are made. Upon the inner surface of the skull the brain makes certain definite impressions. It leaves grooves in the bone where great arteries run. It shows deep indentations caused by the convolutions. It contains other landmarks indicating the size and position of certain prominent features in the brain. These casts do not show the brain characters in all their sharp details because within the skull the brain is covered by three layers of membranes and surrounded by a thin jacket of fluid. In consequence, all of the prominent characters, although easily recognized, are somewhat veiled. It is for this reason that we are unable to detect every coil and groove in a brain cast of a fossil skull. We may, however, discern many important features and thus form an accurate estimate concerning the brain characters of several prehistoric races of man. Many casts of this kind are now available for study.

It is probable that a number of distinct species of prehistoric races have passed away leaving no trace of themselves. Even the bones of man's body gradually crumble into dust unless, by some fortuitous circumstance, they are slowly converted into stone through the deposit of mineral salts. It seems likely that only a few of man's skeletal remains have been preserved for us in this manner. By far the vast majority have gone the way of all flesh and most bones. The few precious relics that we thus far have had the good fortune to discover are treasured as rare possessions. They tell us in a somewhat disconnected way of many ancient people who have lived long before our times. Yet, however disconnected this story may be, however wide its gaps, however serious its omissions, it would be improper to overlook the fossil evidence of these early people. The fossilized relics must be permitted to set forth the story which they have to tell while we endeavour to keep our interpretations within the bounds imposed upon us by the nature of the evidence.

Brain of Java Ape Man

The brain cast representing the most ancient race of men yet discovered is that of the ape man of Java (*Pithecanthropus erectus*). Dr. Eugen Du Bois, when he made his wonderful discovery in Java, found almost the entire skull cap of this primitive man, who lived somewhere between 500,000 and 1,000,000 years ago. His brain was remarkably small. It was not nearly so large as our modern brain or even as the brain of many other prehistoric people. Its capacity was only 940 cubic centimetres. This is small for a human brain, which ranges between 1000 to 1400 cubic centimetres. But if it is small for a man, it is much larger than any ape brain. An interesting comparison as to the size of the ape man's brain is afforded when the brains of a large gorilla, of the Java ape man, and of a modern man are placed side by side. At once the differences are apparent. The brain we are now considering clearly occupies an intermediate position between the gorilla and modern man.

The striking feature about the brain of the lowly ape man is the great expansion which has taken place in the department and permanent headquarters of the highest mental faculties—the frontal lobe. Compared with the brain of the gorilla, there can be no dispute as to the great advantages held by the ape man in this part of his brain. The convolutions are plainly shown in this frontal area. In fact, these coils are more prominent in this region than elsewhere. This fact does not imply that the convolutions in the brain are supreme in the frontal lobe of the ape man. If they seem less prominent in the other lobes it is only because the frontal coils in all cases make more positive impressions upon the skull. It is fortunate, though, that these coils may be so clearly seen in that region of the superbrain which reveals the development of the highest faculties. We should also bear in mind that this department of the chief executive in the frontal lobe is preëminently a human possession. A comparison with the gorilla's brain shows at once the great expansion which has occurred in the most responsible portion of man's superbrain. In consequence of such frontal growth the human race distinguished itself in creation by acquiring all that is implied in the title *Homo sapiens* (man of wisdom).

Another decisive feature appears in this frontal region. The left convolutions are slightly larger than those on the right side. In all probability this difference in size indicates that a highly characteristic human quality has already been introduced. In the ape man the right hand already appears to have become the leader in all the varied skillful performances of manual achievement.

Speech

In this early period it seems likely that man was using his hands for constructive purposes. Of far more significance and bearing more decisively upon the destiny of humanity is the appearance of a well-marked coil in the lower portion of this frontal lobe on the left side. In all living races of man this convolution is associated with the control of spoken language. From this specialization it is apparent that the ape man had acquired the powers of speech. Even if his frontal lobe were small, it far surpassed that of any ape however highly developed.

It is clear from these facts that the primitive ape man of Java had risen to a plane far above the gorilla, although he was still much below that of modern man. Visualized from his brain, this Java man must have had increased powers of reasoning. He must have been capable of making better adjustments to life than the gorilla or any of the great manlike apes. He possessed the ability to build up a greater sphere of experience and make some approach to human personality. His tendency to right-handedness was a distinctly human character, around which are built many of man's most productive specializations. In all of his qualities the Java man was much below his later human successors. It is difficult to estimate how much skill he had acquired with his hands, but it seems almost certain that he added one supreme advantage to the motor equipment of animal life. HE HAD LEARNED TO SPEAK—to communicate in verbal language. The animal machine had acquired a new means of expressing itself. It was capable of developing a new output in the production of which it became highly prolific.

Several theories have been advanced to explain the development of human speech. One of these attributes the origin of language to gestures, especially those made with the hands. Gestures indicating direction, location, distance, size, shape, motion, number, and many other specifications became associated with vocal expressions. These symbols were the basis of language, which required special speech centres in the brain for its control.

This means of communication laid the foundation of all human knowledge. Doubtless the linguistic ability of the Javan ape man was extremely crude, but he had taken a decisive step in a direction necessary to the further development of mankind.

More Effective Use of the Senses

In the department of his body and contact senses the ape man's brain shows marked advances over the apes. The expansions here must be regarded as particularly connected with the free use of the hands and arms and the assumption of the erect posture. A much richer supply of raw materials in the way of sense impressions from the legs and arms, and from the body, generally speaking, made possible a more effective turnover and output of nervous energy. During this time man was learning many new uses for his hands in devising original means for maintaining and advancing his footholds in life.

The departments of sight and hearing situated respectively in the occipital and temporal lobes of the brain show that degree of expansion which supplied greater human powers. Man could see, and understand better what he saw. He could hear, and understand more fully what he heard. He was capable of more effective appreciation of his surroundings. If he obtained a better idea of the world through his sense of sight, he put these more ample impressions to better use in the visual direction of his actions and more especially in guiding the work of his hands by his eyes.

If his sense of hearing likewise gave him better understanding of the audible world about him, it was most important in that it contributed to the upbuilding of his vocal speech. Sounds which he heard began to have new meanings to him. From this it was but a step to translate such sounds into spoken words with fixed meanings of their own.

In all of these particulars the brain of the ape man had made definite advances. It was superior to all of its forerunners in the animal kingdom. The fact that it had thus advanced brings to mind many perplexing questions. Why had this great change taken place? What causes had produced the marked extensions in the frontal lobes and in all other lobes, sufficient at last to lift man up to a human level? Attempts to answer such questions venture into the field of conjecture. Many factors yet unknown may have been the real causes in producing this remarkable change.

The Human Hand and Foot

One great difference between man and the manlike apes seems to be based upon the character of the feet. Man had at length acquired two feet upon which to stand upright and make his way. His erect posture had caused many changes in his body, including the position of the head, the relation of the eyes, and the length of his limbs. None of these changes had more telling effect upon human destiny than the final freeing of the hands for occupations other than locomotion. In this way man acquired his most useful advantage—the hand. It became his chief reliance, the basis of his constructive abilities, and the guide of his analytical powers. It has been the achievement of his hands that has carried man onward. Some authorities believe that brain development was the chief factor in human progress. Such no doubt is the case, but it was the hand that called upon the brain for its progressive development.

Whatever other factors were at work, the hand was one of the most potent influences in the rise of man. With the brain to direct its action, to expand its usefulness, with the upright posture to give free range to its executions, with speech to make its accomplishments available to all, the hand became a master key, opening all the ways leading through the vast domain of human behaviour. If the influences which determined human emergence from the lower levels of animal life might be catalogued as a working theory, they would perhaps appear in the following order:

1. The development of the human foot upon which to establish the erect posture.

2. The freeing of the hand in consequence of the erect posture for the purposes of human success.

3. The expansions of sight and hearing for the better appreciation of the world and the more effective guidance of action.

4. The development of speech.

5. The establishment of human personality and the development of higher mental faculties. For the successful administration of these special powers, a brain of at least human capacity was necessary.

Brain of Piltdown Man

When Mr. Dawson found the fossil remains of the Piltdown Dawn man he brought to light another view of the human prehistoric brain. There are many indications that the Piltdown men had made great strides in their brain power. This is especially apparent in the frontal lobe. The convolutions are prominent, especially that one upon the left side which plainly indicates the power of speech. These early inhabitants of England must have been more gifted than the humbler ape man. Such at least is the evidence of the frontal lobe in which the department of the highest mental faculties was much better developed. Similar advances appear in the parietal regions, suggesting that the hands of these Dawn men had acquired increased capacities as constructive agents and sensory organs. The large expansion in the department of body and contact senses plainly signifies great advantages gained in exploring the world. Piltdown man must have understood the consistency, the texture, and shape of the things he touched. The weight and mobility of objects gave him information concerning their use. The advantages of wood and stone for projectile and penetrating purposes, the utility of sharp edges, the flexibility and tensile strength of various tissues, like the bark of trees or climbing vines, all came to him as revelations evoked by his new powers for sensing his world. These revelations were of much service in other ways. The Dawn man could utilize these sense impressions in directing new actions which helped him to overcome obstacles or to gain greater security. He could now combine stick and stone in a manner advantageous for his daily contacts with life. There may be some question whether the earlier ape man of Java had learned the secret of making implements for himself. With the Dawn man of Piltdown the case is different. It seems most likely that he had already established the industry of instrument making. Some students of this question still hesitate to believe that the dawn flint implements (eoliths) found in association with the Piltdown remains were really the product of human hands. It is probable that the Dawn man already possessed the great advantage of being right-handed. The chipping of stone implements would make it necessary for him to hold the flint in one hand and flake it skillfully with the other. The departments of hearing and sight both show an expansion similar to that in the other parts of the brain.

The Piltdown brain is superior to that of the Java ape man in all particulars. It indicates the power of speech, the development of right-handedness, and the establishment of higher mental faculties. It also attests that the Dawn man had come a long distance from that parting of the ways at which the human race separated from the great apes.

The Neanderthal Brain

The time assigned to the Dawn man's day on earth varies considerably according to different estimates. The latest calculations place this time at a little over a million years ago. By comparison, Piltdown men were certainly more ancient than another race which dominated Europe for long ages. This was the famous Neanderthal race. These early and long extinct people migrated into Europe from the East. Their scattered fossil remains found in many different parts tell the same story of an unusually powerful race. In stature they were relatively short, probably not averaging much more than five feet three inches in height. Their arms were long and powerful, their necks thick and extremely muscular. Their legs were heavy and slightly bent at the knees. As a race they were distinguished by the shape of their heads and the size of their brains. The Neanderthal had a low, retreating forehead and a head that was peculiarly flat near the top. It seems as if the head were especially constructed as part of an effective fighting machine. Heavy ridges of bone surmounted the eyes much as is the case in the gorilla. The head was set down well upon the shoulders. The jaws were heavy, indicating that the teeth as well as other parts of the body might be employed in combat. The nose was broad and flat and the chin lacked prominence. All of these features must have given the Neanderthal man a brutish appearance. The low beetling brow, the flattened vault of the skull, the heavy jaw with receding chin, the broad flat nose, all gave him a countenance not unlike that of the great apes. Visualized from his fossil remains, the Neanderthal was a savage-looking creature. He would have been a dangerous wayfarer for the unwary to meet. He was probably so hideous in his appearance that his presence gave offense to men of more refined sensibility. This seems like a harsh judgment upon the Neanderthal. It is a low estimate of him which his brain does not justify. As a matter of fact, the size of the Neanderthal brain is somewhat greater than that of any modern races. If size alone were the standard, such a brain would not indicate a low degree of mental organization. But size alone is not a reliable indicator of brain capacity. Unusually large brains are often inferior in their brain power. It is said that the largest brain, both by weight and measure, was that of a feeble-minded gardener at one time employed in a large public garden in London. The volume of the Neanderthal brain is not a convincing argument as to its efficiency. From other indications, however, it is certain that this race had made definite advances in human progress. They were skilled artisans and flint workers. They had command of fire, which was employed in the upbuilding of distinct industries. Far from being lowly, ape-like creatures, they had many of the higher attributes of man.

The earliest discovery of these ancient people occurred in 1848 when Lieutenant Flint found the first Neanderthal skull in an old quarry at Gibraltar. The real meaning of this find, however, was not appreciated until more than sixty years later.

One of the most important Neanderthal discoveries was made in the valley of the Dordogne in southwestern France. In a cavern near the little village of La Chapelle-aux-Saints, the abbés Bouyssonie and

Bardon (autumn, 1908) found the skeleton of a primitive man. The body rested upon its back, with its head toward the west, its legs, thighs, and forearms folded together. The head had been protected by flat stones, and many skillfully worked flints of the Mousterian period surrounded the body. There was every evidence of interment and burial ceremony about the discovery which, it was finally decided, was the skeleton of a middle-aged man belonging to the Neanderthal race. By measurement it was found that the skeleton must have contained a brain of large size, considerably larger than the average modern brain. The brain cast of this prehistoric man gives us some clear idea of Neanderthal brain power. In shape the brain is distinctly flat. The arching in the region of the forehead, so prominent in modern races, is absent. This part of the brain seems to sink inward as if the frontal lobe had gone somewhat into eclipse, or had not yet made that decisive expansion characteristic of later races of man. This condition, however, corresponds exactly with the low retreating forehead of the Neanderthal. When compared with the ape man of Java, or with the Dawn man of Piltdown, the Neanderthal brain does, however, show expansion in all of its major departments. The parietal, occipital, and temporal lobes have all increased in size. This is true also of the frontal lobe, but the ratio of expansion appears to be less here than in other areas. It is in this department that the real flatness of the brain is most pronounced. The convolutions in the frontal lobe fail to give the superbrain those dominant characters which produce a high, wide forehead in modern man. This apparent failure of the frontal lobe to attain greater proportions must have had far-reaching influences upon the life and destiny of these primitive Europeans.

All of the major departments of the brain show considerable expansion. The entire brain of the Neanderthal gives evidence of progressive development at the same time that it manifests many signs of deficiency and incomplete realization along the higher lines of progress.

Brain of Rhodesian Man

Asia and Europe have produced evidence of prehistoric man. Until quite recently Africa has been peculiarly silent in this regard. At length even the Dark Continent has revealed signs showing that man of a primitive type has gone a long way toward the south in his wanderings over the earth. This important discovery was made in Rhodesia and first publicly reported in 1921 by Mr. William L. Harris. The conditions of this discovery were peculiar and significant. Actual remains of two human skeletons were found at Broken Hill mine in northern Rhodesia. Connected with this mine there was originally a natural cave about 120 feet long. This is known as the bone cave. It contained a vast number of animal bones all impregnated with the salts of zinc and lead. At the bottom of this cave the human remains were found. Like all of the other bones, the human skeletons were incrusted by zinc and lead. The cave itself seems to have been the ancient feasting place for hyenas, which dragged thither their prey. There is some suspicion that these human remains may have come to their last resting place in the cave of bones in a similar manner. The cleft of the roof of the cave here is far in, which suggests the possibility that the men or women whose bones were found may have fallen into the cavern. Certain features of the skull, however, have convinced eminent authorities that these individuals belong to a very ancient prehistoric race. The face is far more brutal than that of any other known human being, living or extinct. The enormous eyebrow ridges resemble those of the gorilla, the nose is flat and has that snout-like appearance suggesting a peculiarly significant mark of the beast, known only in one other extinct member of the human family, the Neanderthal man. Another remarkable feature of the head is the great size of the palate and teeth. The brain case and the features of the brain lend support to the view that this Rhodesian man was even older and more primitive than Neanderthal man.

By all the signs of his frontal lobe the Rhodesian must have been a humble sort of human. Nothing in this department of his brain suggests any near approach to the attainments of modern man. The frontal lobe bears many marks of ape-like characters. It indicates at the same time a brain power which surpassed the limits of the great apes. It was a brain fast carrying man upward to the broader plains of human experience. The lot of the Rhodesian must have been precarious. He was pitted against formidable animals of the African wilds. But, judged by his frontal lobe, his brain had not left him destitute for the exigencies of such competition. He doubtless possessed the power of speech and the capacity for making human combinations. Compared with lower mammals he had a more facile association of ideas and could profit more effectively from experience. The evidence of his parietal, temporal, and occipital lobes indicates definite progress in all departments of sense perception. His brain was human though still in the rough. Whatever position is finally assigned to this far-distant cousin in our human family, he seems from his brain to have been a very simple sort of human being, older perhaps and even more primitive than any of the Neanderthal race.

Changes in Human Race Extremely Slow

It is impossible to give the exact dates for the appearance of the different races of prehistoric men. At best, our ideas concerning their antiquity must be approximate. Yet these fossils do not leave us in doubt in one respect at least. We know and we may prove our knowledge in many different ways that man has inhabited the globe through long ages, whether we rate these ages as hundreds of thousands or millions of years. Throughout these ages man has varied considerably. At first he bore many close resemblances to lower forms of life. Slowly he improved and manifested a progressive advance toward higher humanity. We may be inclined to question this progressive change from one stage to another largely because our own experience of life is limited to such a short span of time. Within the memory of any man the changes in his fellows seem inconsiderable. Mankind appears to have a dominating fixity in appearance. It is only a little more than sixty generations since the birth of Christ, and during this time the racial characters of men have changed but little. The white man, the red man, the black man, and the yellow man, are all much the same in the form of body, the shape of head, the appearance of face, as they were sixty generations ago. There is more than a striking figure of speech in the scriptural definition that a thousand years are but as a day in the endless expanse of time. Measured by such days as these, man has changed slowly but surely. When we contemplate long days of this kind, each of a thousand years, their accumulation in the existence of our race takes on a new meaning. Estimate, for example, how far back ten days of this time would take us. We should find ourselves in the life of the world as it was ten thousand years ago, in that critical period when a vast social and racial change was altering the colour and complexion of human existence in Europe. The senile but still wonderful Cromagnon race was then limping along to the last stage of its declining old age and was about to disappear. The hardy and practical man of the New Stone Age had already arrived and was fast becoming master of the situation. The Cromagnon artist-hunter was passing the sceptre of human control in Europe over to the hard-headed

Neolithic business man. Another fifty days (each of a thousand years) still further back and we find again a momentous crisis. At that time the Neanderthal man was passing. In spite of all his rugged vigour, his day on earth was done. He had carried on existence successfully for seven or eight hundred thousand years, but now the time of his extinction was at hand. These seven or eight hundred thousand years would merely be seven or eight hundred days, according to the new kind of timepiece by which we are endeavouring to measure the duration of human progress.

Cromagnons Replace the Neanderthals

We may pause to seek some reason for the momentous change when the Neanderthal appears to have bowed before the Cromagnon. The real secret in the failure of the old race and the success of the new may be found in the brain. It was the increased brain power of the Cromagnon which produced the supremacy of this great race. It was this power which gave Europe its first pioneers in art and, for all mankind, opened the doors of creative imagination and appreciation of beauty in the world.

It would be particularly illuminating if a brain of the Cromagnon race were available for study. These first artists occupied an exalted position. They began their life in Europe about fifty thousand years ago and carried on their industries for a period twenty times longer than the duration of the Christian Era. At present there is no Cromagnon brain cast available. We may, however, draw analogies from certain of their human contemporaries, who lived in the middle part of Europe during the Solutrean period. These were days when Cromagnon art and industry were at their zenith, when the Old Stone Age had attained its culminating stage and flourished in its fullest development. The Solutrean contemporaries of the Cromagnons were themselves a remarkable people. They are known as the "great mammoth hunters of Prêdmost." Their fossil remains have been found in Moravia. Associated with them were the fossilized bones of nearly nine hundred specimens of mammoths. In addition to these fossils of men and beasts there were found many highly worked flints, including spear heads and other stone implements, all having a pattern which belonged to the Solutrean period. At Prêdmost, where this discovery was made, there was a collective burial of fourteen human beings, with the remains of six others. These great mammoth hunters must have been a large and powerful race. Their prowess as trackers of great game was exceptional. The character of their brain as revealed by the casts made from their skulls places them at once on a plane higher than any of the earlier races of man. In fact, it admits them to membership in the same race to which we ourselves belong—that is, *Homo sapiens*. These intrepid hunters, according to their fossil remains, closely resembled their splendid contemporaries of western Europe, the Cromagnons. Of these latter there is an ample record in consequence of which they will always rank among the best representatives of the human species. Their remarkable artistic contributions denote far more than the executive mastery of art. They signalize that new spirit which had been breathed into mankind, that devotion to the beautiful in life which created an abiding enthusiasm in all of our race for its highest ideals and loftiest purposes. From the first days of Cromagnon life these tendencies were dominant. They were a people who delighted in the lavish use of personal adornment. Coiffure was of particular interest with the women and a highly developed personal achievement. Both the men and the women seem to have been fond of using red and yellow ochre, much as in modern times, to beautify the body. If certain Egyptian ladies are credited with the invention of the lipstick and of rouge, it is probable that they found their examples for such artistic practices in these Cromagnon prototypes. Drawing, painting, and sculpture were not the only creations of the Cromagnons in the realm of art. It seems probable that they had invented some form of music. Their sketches of dances and masks make it seem likely that to vocal expression they had added certain artificial accessories in the shape of crude musical instruments. One character in the artistic discrimination of these artists and sculptors of the Old Stone Age is of unusual interest. It shows a distinct partiality for portraying women of extreme corpulence. Many of their statuettes have been discovered which, in spite of their somewhat unsightly *embonpoint*, are called Venuses. The most famous of these is the Venus of Willendorf. It was, however, in the carving of animal forms that Cromagnon art attained its real heights. Many living and extinct species of birds, mammals, and fish have thus been immortalized. Back of all this varied artistic creation there must have been a social organization of high order, for only a rich human experience could provide the soil for such vivid and real beauty in art.

The Mammoth Hunters of Prêdmost

The brain of the great mammoth hunters of Prêdmost had a volume close to the standards of modern men. It had lost those marks of inferiority which stamp the brains of lower races. It had gained that refinement of structure in the superbrain which proclaims the ascendant qualities of humanity. The groove of Sylvius and the central groove show the boundaries and the size of the several lobes of the brain, which correspond closely to those of modern man. It is in the frontal lobe that the most remarkable gains are apparent. The convolutions in this region are prominent and well defined. That flatness so typical of the Neanderthal brain has disappeared. These Prêdmost and Cromagnon people were not a race of flatheads, such as were the Neanderthals. The human forehead had become high and broad. It was no longer ape-like and receding, but clearly indicated that the human brain had developed sufficiently in its latest acquired and most highly organized department to demonstrate that man at length was capable of real humanity.

From the Java ape-man up to *Homo sapiens* of modern times there has been a slow but gradual increase in all of the important measurements of the brain. There has been a gain in length, in breadth, and in height. Much of this gain has taken place in the region of the frontal lobe, and thus has expressed itself in expansion in the highest department for developing brain power. The meaning of this pronounced frontal expansion is evident in the progressive extensions of human intelligence.

Progress of the Human Family

Judged by its brain power, the human family has clearly been progressive. In this respect it differs from all other families in the animal kingdom. In various parts of the world mankind has lagged behind. Such is the case in the tropics, where the races of men are still in a primitive stage. This is true also of many islands of the sea, in the arctic regions, and in other remote and inaccessible places of the earth. But given its full opportunity the human family has not failed to go forward. The line of its progress may not be deemed wholly satisfactory by the higher standards of enlightened criticism. Yet in bending the forces of nature more and more to his will as well as to his convenience, man has surely progressed. Where he has stood still, where perhaps he has even fallen behind, is in the manifest lack of control over his own nature. His curiosity has led him to inquire into every phase and aspect of life upon the globe. But in all of these inquiries he has given far too little thought to himself. Only within recent years has he become deeply interested in the mechanisms of his own behaviour. Least of all has he devoted time and thought to the organ of his chief reliance, to the creator of his successes, to the dictator of his future.

Since his earliest beginnings man has grown in humanity as his brain expanded. Such a conclusion seems irresistible. If we place side by side the brain casts of the ape man of Java, the Dawn man of Piltdown, the Rhodesian, the Neanderthal, the Prêdmost, and the modern, we have before us a demonstration of this progress more effective than words.

The regions in which the greatest development has occurred are easily discerned. Marked additions have been made to the department of sight in the occipital lobe, of hearing in the temporal lobe, of body and contact sense in the parietal lobe. The mechanisms for the amplification of sense perception and sense combination have been manifoldly increased. But it is in the department of the chief executive of life and experience that the most decisive advance has occurred. This area of the frontal lobe, so poorly represented in man's nearest kin, the great manlike apes, shows exuberant growth, even in the ape man of Java. Here its features correspond to those of modern man in nearly every detail. Its only essential inferiority is its relative smallness. Its special development of convolutions denotes the acquisition of human speech and human reason.

Progressive Development of the Human Brain

Were we to select any single area in the superbrain as the department supreme in mental organization, we should not neglect the claims of the department for vision, for hearing, for body and contact sense. Although each of these has progressively expanded, we would be much more strongly inclined to favour that part of the superbrain which has been active as the superlative sense combiner, which has served to develop the fullest impressions of human existence, to accumulate the widest ranges of experience, to direct most broadly the actions of our behaviour. Traced through all of their intermediate stages upward, it is these frontal regions which manifest the most conspicuous development. The process of this long, progressive expansion in the frontal lobe reaches back to the earliest periods of man's existence. It conveys an accurate impression of the manner in which the brain has responded to the demands made upon it. The human brain may still be considered to be in its early youth, in spite of the fact that more than a million years of human striving lie behind it. This great antiquity, this remarkable flexibility, have been largely overlooked. By most of us the human brain is regarded as a finished product. Its long, prehistoric record as we know it to-day does not support this point of view. On the contrary, it makes it appear far more probable that the brain of modern man is only some intermediate stage in the ultimate development of the master organ of life. The greatest possibilities for future progress lie in further expansion of the frontal lobe. For this reason the brain of prehistoric man is not merely an antiquarian relic, it is a sign from the long ages of the past showing the road man has followed in his upward course. It likewise conveys some suggestions concerning the future. For, if the human brain began as a simple organ and gradually developed through successive stages, there is reason to believe, if not to predict, that it may develop still further.

CHAPTER XII

IMPLEMENTS OF HUMAN SUCCESS

HOW THE HAND, FOOT, AND BRAIN LED THE WAY TO HUMANITY

It is not sufficient to know that the brain began as a simple organ and gradually became more complex. Sooner or later we must learn the reasons why it made this progress. At present we are able to identify some of the essential principles underlying brain development, yet with few exceptions the exact causes are still obscure. We may feel certain, however, that the progressive advances were due to the accumulation of slight changes which, modifying brain structure ever so little, ultimately made it more highly effective. Such changes in the different parts of the body are the result of a complex interplay of influences acting upon the animal as a whole. The brain has been particularly responsive to this interplay. It has at the same time been thoroughly conservative. Throughout all its wide range of variation it has maintained its basic designs. If readjustment of the body to certain conditions has resulted in the depreciation of a special part, such as the eye, the structure of the brain shows corresponding depreciations. The principle of compensation has also been at work. The power which may be depreciated or lost in one department is, to some degree at least, compensated for by others. An illustration of this compensatory power is afforded by the mole. This animal lives a burrowing life beneath the ground. Light rays do not reach it, and it therefore has no need for vision. In consequence, its eyes do not develop the function of sight. Its senses of touch and hearing, however, are greatly amplified, and the structure of its brain gives evidence of this compensatory readjustment.

Signs of the close relation between the brain and the parts which it controls may be found in many organs of the body. In some instances these signs are outspoken; in others they are less clear. It is much easier to find evidence of this correlation in those parts which play a conspicuous rôle in life. The arms and legs, the eyes and ears, are particularly good examples. Modifications which have affected these parts are distinctly reflected in the brain. If more brain power is required for their better operation, more ample provision is made for them in brain structure.

Relation of One Part of Body to Another

It is a debated question whether the brain or the external part of the body takes the lead in progressive modifications. Some authorities believe that all advances of this kind are dictated by development in the brain. Others ascribe the determining influence to the external part. For the present it seems wiser to consider these modifications as simultaneous, as affecting the external part and the brain together. Certain dangers arise from regarding the body as divided too strictly into definite parts. Such a division has advantages for purposes of description, but it may tend to obscure the important fact that life is carried on by the body acting as a whole. In this light the division between external part and the portion of the brain controlling it establishes an artificial distinction. Viewed in the light of purposeful life, one is of little use without the other. Both external part and the portion of the brain controlling it establish a special unit which, coöperating with all other special units, carry on the process of living.

This view is known as the organismal conception of life. It estimates the entire animal not as a collection of different parts but as a combination which makes life possible. According to this conception the external structure (arm, leg, eye, ear, etc.) and the portion of the brain controlling it form an operating part of the whole. Modifications in the one are reflected in the other. They cause mutual reactions. When eyes are developed for different kinds of vision, corresponding provisions are made for them in the brain. When legs are specialized for various kinds of locomotion, brain structure adapts itself accordingly.

It is important to realize what the eyes and the ears and the organ of smell have contributed to the progressive advance of the brain. In all of these organs there is a marked constancy and sameness among animals possessing them. Structures presenting a greater variety of form might have even greater pertinence. It therefore is a more leading question to ask what relation the brain bears to the extremities, to the fore and hind legs, to the hands and feet.

History of the Hand and Foot

There is a long history of progressive change back of the hand and foot. In their development they emerged from more simple structures connected with the ends of the limbs in certain four-legged animals. Because they are attached to the limbs in this way, they have played an important rôle in one of the chief activities of life—locomotion. The fore and hind legs act as a series of levers. They are moved by muscles and in this way make transportation possible. Consequently the modifications in the ends of the limbs in response to special types of locomotion have a most important bearing upon the life of the animal and thus upon the brain.

In animals living upon land such parts of the limbs as touch the ground are modified by many factors; thus the weight of the body, the speed of movement, and the kind of locomotion would all exert their modifying influence. Limbs of several different designs have thus been produced. Heavy animals, like horses and cattle, which require speed and endurance for long journeys, need hoofs. Still larger hoofs were developed by heavier animals, like the elephant and rhinoceros. The paw was the design utilized by animals like cats and dogs. Their bodies were not so heavy as those of horses and cattle. They were capable of great speed and needed sharp nails on their paws to hold the ground in running and springing. These talon-like nails they also used for defending themselves or in capturing their prey, as do the lion, tiger, leopard, and bear. The paw is a more flexible implement than the hoof. It provides a soft, elastic pad by means of which the animal touches the ground. In animals like the seal, walrus, and sea lion the flipper is the design utilized. Here the digits are connected by means of a web. The wing is the specialization in such animals as the bat whose transportation depends upon flight through the air.

Locomotor Devices

These various devices for moving the body about on the land, in the water, or through the air have been developed by mammals. By such contrivances they are enabled to subsist, each according to its own mode of living. Some of them have returned to a life in the water. The result of aquatic habits in mammals is extremely interesting. The flippers of seals, walruses, and sea lions equip these animals to swim with great ease and speed. They enable them to clamber about on the rocky coast by the edge of the sea, or upon the ice fields of the arctic regions. Because of its apparent limitations, such a life held little prospect for developing the powers of higher intelligence. A flipper is in no sense an efficient implement by means of which to acquire a superior position in the world. The seals and all of their kind, therefore, offer little promise of progress. They are capable of astonishing proficiency in the control of their neck muscles and movements of their heads, but this at best is a meagre advantage. They are somewhat better off than another group of mammals which took to the water, namely; porpoises and whales. Nothing in the equipment of these animals could serve as efficient instruments by which to gain a pre-eminent place in nature.

By developing wings in connection with their limbs the bats were also excluded from the lines of higher progress. However effective they are in flight, their wings could not be made to serve constructive purposes.

Animals with hoofs, such as horses and cattle, elephants and rhinoceroses, acquired solid and reliable feet for withstanding the heavy strain which their speed and weight imposed upon them. Hoofs, however, are far from ideal as universal instruments. Although sufficient for the work they have to do, they cannot be utilized for purposes other than those of transportation except, in a certain minor way, for offensive and defensive tactics. In these animals all of the digits are either bound together in one large supporting pad, as in the elephant, or are encased by a horny covering, as in cattle and deer. In the modern horse but one digit persists, and this is surrounded by a heavy, horny hoof. Such an implement would not require a highly specialized endowment of brain power for its control.

The daily programme of these animals, limited largely to transportation, calls for no constructive ability and no intentionally destructive one. The hoofed animals possess no means for accumulating or storing food in preparation against a day of need. They are forced to move from place to place in order to find their browsing and grazing lands. They cannot stand against great changes of climate or season. They must flee before the advance of winter as well as from their enemies. The hoof for this reason offered little promise for the development of a more efficient kind of instrument. Such hoofed animals as also possess a trunk developed an accessory organ of much value. It is doubtless an important factor in the high specialization of the elephant's brain. Even this flexible instrument, however, has its decided limitations.

All of these mammals, whether hoofed, flippered, or winged, have failed to develop a brain of superior qualities. In no instance is it an organ capable of a high degree of learning or intricate control of life. The hoof of the horse, cattle, deer, elephant, rhinoceros, and the like set the stamp of the wild upon these animals. This is the keynote of their behaviour. Flipper and wing are equally indicative of inferior qualifications in so far as efficiency and brain power are concerned. There may be sufficient reasons for placing these mammals in the same bracket with man in the great classes of the animal kingdom. Their inferiorities are apparent, however, when their intelligence is estimated by human standards. It is then clear how far below the human level of brain power they are.

The Paw in Relation to Hand and Foot

In our search for animals capable of a greater range of adjustments we will find another group with a much more promising locomotor equipment. This group comprises those mammals possessing paws, such as dogs, cats, bears, rats, squirrels, and the like. In itself the paw is a most flexible implement susceptible to many modifications. It possesses five distinct finger-like processes or digits, each of which is capable of some degree of individual movement. The digits may be spread out or drawn together; they may be folded or extended. In every typical paw there are eighteen movable joints, each of which is capable of some independent motion. Twenty-five muscles make more than seventy separate movements possible. These figures afford some idea of what a complex structure the paw is. Attached to the extremity of each digit is a sharp claw-like nail, beneath which an enlargement in the skin forms a prominent "tip pad." Over each of these pads the skin is arranged in ridges. The ridges roughen the surface and produce what is called "friction skin." The roughened skin and the claws at the end of the digits give the animal better ground-gripping powers. In addition to the tip pad, each typical paw has four enlargements where the digits come together. These are the "palm" and "sole" pads. They are likewise covered with ridged friction skin. The paw terminates in the wrist or ankle, and at this junction there are two enlargements called respectively the "wrist" and "ankle" pads. They are also covered with friction skin.

This design of paw with its separate digits, its claw-like nails, and its eleven pads affords an especially adaptable structure from which to create many different kinds of useful implements. In the gnawing animals, like the rats and squirrels, the paw is developed particularly for running and climbing. The long sharp claws serve the purpose of spurs which, as in the case of the squirrel, may be driven into the bark of trees. All of the pads in the paw come in contact with the surface over which the animal is moving, thus giving information concerning its support and aiding its transportation.

In moles and burrowing animals the hind paw retains its usual features, while the fore paw is converted into something resembling a shovel. The paw becomes broad and flat, particularly in the moles, and there is no suggestion of any of its pads. Since this specialization is adapted principally for digging underground, little could be expected in the way of high attainment for animals of this kind. Their burrowing capacity is excellent, but this is the extent of their ability.

Special Uses of the Paw

In the meat-eating animals, like the dog and the cat, the individual digits and the claws are somewhat shorter, but their most important modification is the fusion of the paw pads and the reduction in the first digit. This change is a specialization for their more springy type of locomotion. Such animals run on the tips of the digits, using especially the second, third, and fourth digits. The paw pads usually fuse to form one or two which serve to increase the spring of the animal. The fore limb of the rat may be accepted as the working model, because it has all of the general features that make up a typical paw. It provides for running, climbing, clinging, and clawing. When compared with the paw of a mole, the modifications necessary for a good digging implement are clearly seen. The pads are no longer needed and might, as a matter of fact, be in the way. The digits are shorter and the whole hand is broader and more scoop-like. The paw of the mole is modified for the work it has to do and has lost many of the structures necessary for ordinary locomotion over the ground. Long claws are no longer essential for climbing or clinging, and the nails have been converted into burrowing ground-breakers. The rabbit and the guinea pig show changes in the fore paw necessary for rapid transportation in a kind of jumping locomotion. They have lost the specializations in the paw necessary for climbing. The nails and the digits are less long and somewhat heavier. The squirrel, on the other hand, has a fore paw specialized for climbing trees. This modification has emphasized the length of the individual digit and particularly the length and sharpness of the claws. Often the squirrel may be seen sitting upon its haunches holding between its fore paws a nut, the shell of which it is attempting to crack with its teeth. Such grasping power is not found in the paws of animals specialized for running and jumping solely. The squirrel's modification of the front paw is extremely important. It reveals how the animal's life in the tree has lengthened the digits as well as the nails. Some degree of power for grasping small objects has come through this lengthening. The fore paw of a cat compared with that of a dog illustrates other important specializations. Both of these animals are strong runners. In running they travel along on the tips of the digits. For this reason the tip pads and the friction skin over them have become highly developed for ground-gripping purposes. The paw pads and the wrist pads have tended to fuse in order to give an elastic surface necessary for that springy gait determined by running on the tips of the digits. The individual digits are somewhat longer in the cat than in the dog. The claw-like nail of all the cat family is one of their distinguishing features. By means of these claws they are able to climb trees, which is a provision of great service in procuring food. Dogs, on the other hand, have short digits, with thick, heavy nails suited more as spikes in running but not adapted to climbing. In many of the great cats, like the leopard, climbing trees is an essential part of their hunting strategy. For this reason they require long, sharp claws, which may also be used as weapons in attacking their prey. The long claws of the bear likewise indicate a modification of the fore paw in adjustment to the animal's climbing propensities. The great weight of the bear makes it necessary for it to have these long spur-like claws in order to get a proper grip on the bark of a tree when climbing.

Transformation from Paw to Hand

Illustrations of this kind might be multiplied to show that in all animals having paws these implements have been modified in one way or another to suit the kind of work they have to do. In the main, this work is transportation. But there are many special problems in the different kinds of transportation. There are also numerous other adjustments to life that are capable of producing profound modification in the paws. From such facts as these it must be clear that the paw has been serviceable as the basis for developing instruments suited to many special purposes. One prominent feature in the several modifications of the fore paw is the effect which climbing has had upon the length of the digits and upon the length of the claw-like nails. In the rat and particularly in the squirrel these effects of climbing are especially distinct. When climbing at length became a dominant factor in the life and livelihood of the animal, certain still more decisive modifications were produced in the paws. We may now endeavour to gain some idea of that important transformation which occurred when certain groups of animals took up more or less permanent life in the trees. These mammals were representative of the monkey kind. They did not resort to tree climbing as many others have done as an expedient in hunting or in escaping from their enemies. The trees became their abodes. Many changes were induced by this new adjustment to life, changes which affected the muscles and bones and even the skin. During the process of this adjustment certain ridges upon the skin in the palm of the hand and sole of the foot began to show marked changes, probably because they were in such immediate and constant contact with the branches of the trees. In their basic designs these ridges which form the friction skin may be traced back to the simplest of pawed animals. Their successive modifications offer one of the most certain guides in following the stages through which the hand emerged from the paw.

Each ridge upon the skin of the paw (*chiridium*) is an elevation of the superficial layer which contains, at regular intervals, the mouths of minute canals coming from sweat glands. In its simplest form each sweat gland in regions of the skin not covered by hair (sole of the foot and palm of the hand) consists of a mound-like elevation in the centre of which is the mouth of a sweat duct. With the higher development of the skin, numbers of these little mounds ran together in rows thus forming the friction ridges. Depending upon the pressure and the kind of contact made with the ground or other surface, the ridges of the skin are arranged either in concentric circles, in ellipses, or in parallel lines. They serve two useful purposes: First, they roughen the surface so that it can grip the ground more effectively; second, by the continuous secretion of fluid from the sweat glands, they keep the skin soft, pliable, and sensitive. In this last particular, namely, the sensitiveness of the skin, the ridges also serve in another capacity. They provide proper locations for nerve endings, necessary to the sense of touch in all of its various modifications. Thus the paws in the more minute architecture of their skin pads and friction ridges afford highly pliable and sensitive instruments by means of which different kinds of mammals are able to adjust themselves in a great variety of ways.

After many intermediate stages of transition the fore paw assumed the appearance of a hand. Simultaneous with this change the hind paw also began to manifest many hand-like characters. Potent factors were at work determining this important transformation. Their influences were decisive not alone because they changed the paw into a hand but because they instituted equally profound changes in the structure of the brain. Such modifications as these brought about many adjustments to life destined to be the special determinants of human behaviour. One of the first changes to occur in transforming a front paw into a hand was the direct result of arboreal life. This modification consisted of a decisive lengthening of the digits, particularly the second, third, fourth, and fifth digits. In this way the fingers were formed. The first digit which ultimately became the thumb did not lengthen to the same degree as the other four. The chief influence in producing this lengthening to form fingers arose from the need of a firm grasp upon the branches. Its effects appear in the simplest monkeys, such as tarsius. The small hand of this animal has four long fingers and a diminutive thumb, all of which are well adapted to encircling and grasping a cylindrical branch. Another important transitional feature is the flattening in the ball of each digit. In tarsius each finger tip has a disk-like appearance. This is an extreme development. It produces what in effect is a suction pad on the tip of the finger not unlike that observed in some of the frogs (*Hyladæ*). Such suction pads enable the animal to strengthen its grasp upon the bark. The flattening of the finger tips due to the pressure required in grasping the limb of a tree produced a third great change. It caused a corresponding flattening of the back of the finger tip and thus developed a broad, flat finger nail to replace the sharp, claw-like nail of the cat, rat, and other similar mammals.

The Hand of Tarsius and Lemur

The three changes observed in the most primitive of the monkey kind (*Tarsius*) comprise the pronounced lengthening of the fingers, the flattening of the finger tips, and the flattening of the finger nails. These transformations are easily understood in connection with the necessity of grasping cylindrical branches. In other words, a prehensile hand came into existence as a result of living in the trees, and a new kind of instrument made its appearance in relation with the upper extremity. The need of a firm grasp on the branches was the fundamental cause of this modification of the paw. It had far-reaching effects because it created the facility to grasp many other objects and thus struck the keynote of those further developments which ultimately gave rise to the grasping hand of man.

All of the pads covered by friction skin which are characteristic of lower mammals like the rat and the squirrel may be identified in tarsius. The tip pads are somewhat changed to form the suction disks. The palm pads, four in number, occupy their usual position in the angle between the digits. The wrist pads, two in number, are well developed. By means of these elastic cushions the animal makes its contacts with the branches.

Transition from paw to hand is still more pronounced in the lemurs. These animals in many ways stand lower in the scale than tarsius. In them the lengthening of the digits to form real fingers, the marked development of the thumb, the appearance of friction pads, and broad, flat finger nails are all prominent. The index finger shows certain variations in its development. In other respects these lowly members of the monkey kind manifest definite progress in the change from paw to hand.

The Interesting Case of the Marmoset

At this point it is interesting to consider the case of the marmosets. Here the progress which the paw had made toward a more effective structural instrument encountered a serious setback. The hand of these little animals, in a general way, has much that resembles a paw. Although it has long fingers and a prominent thumb, there is an evident slipping backward. The claw-like finger nails suggest an actual retrogression in the process of developing a hand. If the marmosets were actual backsliders, other monkeys of the New World were particularly progressive. They developed hands which are extremely human in appearance. Their long, tapering fingers have broad, flat nails. Their thumbs are fairly well formed. Their finger and palm pads have characteristic appearances. This interesting group of South American monkeys show in a most striking manner those changes which life in the trees has brought about in the fore paw. Such modifications are especially significant because of their influence upon the behaviour of those animals which have taken up a permanent arboreal life. They have also made a deep impression upon the structure of the brain. The transition from a running, ground-living animal to the simpler arboreal forms is foreshadowed in the lemur's hand. In many respects this transition stands just upon the border line. Its apparent indecisiveness is recorded in the brain, for the lemur retains many of the ancient brain features created by older ground-living habits. At the same time, it indicates certain adventurous attempts to break away from the earth and ascend into the trees. The grooves of the brain show this new departure particularly well. They retain their strong family resemblances inherited through long ages of four-legged ancestors. But added to this they manifest a tendency to assume the characters which in due course would lift their successors farther from the ground and into a more erect posture.

Appearance of the Hand-like Foot

Up to this point attention has been centred upon the important changes which attended the transition from paw to hand. Equally momentous were the modifications in the hind paws which resulted in hand-like feet. This transformation slowly altered the digits, the claw-like nails, and the friction pads. It modified all of these parts in such a way as to produce better limb-gripping instruments. A great change in transportation had taken place. Running over the ground in easy, secure fashion now gave place to the more hazardous method of climbing among the branches of trees. A dependable grip was the prime need. This capacity required long toes with which to encircle the branches, a powerful sole, and a great toe with strong grasping power. The four-legged animals that travel over the ground on various kinds of paws support the weight of the body on two main arches of the foot. One arch consists of an elastic span between the tip and the sole pads. The other arch extends between the sole and ankle pads. Generally speaking, those animals living on the ground first strike the surface at each step on the tip pads of the four outer toes. As the full weight of the body is accepted by the hind paw, the sole pads touch the ground. Last and most lightly, the ankle pads in the region of the heels rest on the supporting surface. In many running animals of this kind the heel touches the ground infrequently. Their running and walking in consequence have a springy quality that prepares them for a quick bounding start at an instant's notice.

Strong Grasping Powers

Animals like the rabbit and kangaroo possess hind legs that work together, while the fore limbs are put forward first one and then the other. The most effective type of transportation in animals possessing paws has developed a gait in which the action of the hind leg of one side follows the action of the fore leg of the opposite side. This is the manner in which the dog runs. It is also true of all members belonging to the great cat family. The hind paw is put down in the footprint of the opposite fore paw. Apparently there is no deliberate supervision of this action which seems to be wholly automatic in its nature. To a great extent, however, this automatic regularity in the hind legs ceased when the four-handed animals came into existence and began to live in the trees. The problem then was a totally different one. It was not necessary for these animals to be on their toes every moment. They did not require the powerful spring formed by the two arches in the sole of the foot. Their chief necessity was a foot that would have the grasping powers of a strong hand. In this way they could make sure of seizing the branches securely.

The first digit of the foot, which in most pawed animals often fails to develop, became of greatest service to the monkeys. In most of them the great toe offers an added means for securing a firm grasp. It may be extended behind the branch while the other toes encircle it and all working together produce a firm grip not unlike a wrench on a pipe. The need of a long lever extending from the tip of the toes back to the heel, essential to the springy gait of the ordinary pawed animal, is not so strongly felt in arboreal life. In fact, a foot which is too long may be an actual disadvantage, while one facilitating the best kind of gripping power would necessarily require a shortening from toe to heel. This was the change which took place in the early beginning of tree life.

Under Direction of the Eye

It is difficult to appreciate all of the decisive modifications throughout the body which the development of such hand-like structures determined. Their influences operated in profound and subtle ways. They caused a great change in body posture. The animal was now able to reach for branches above its head. This was a long step in the direction of standing upright. It modified the relation of the head which in most four-legged animals is directed so that both the eyes and the nose are turned toward the ground. Reaching upward to grasp branches and drawing the body in this direction lifted the head. It has been shown that this action of pushing the head backward and stretching the neck causes the hind legs to straighten out automatically in exactly the position necessary for standing erect. Such a beginning of the upright posture also produced a change in the position of the internal organs of the body as well as in the position of the eyes. These modifications influenced the growth of the superbrain, which finally acquired that appearance seen only in animals possessing hands. Coincident with these modifying factors, still another important change was in process. In all four-legged animals the paws, and more especially the hind paws, operate out of sight of the eyes. The animal does not see their action. The eye does not watch and supervise the movements of the paws step by step, but allows them to shift more or less for themselves. With the appearance of hands connected both with the fore and hind limbs, this state of affairs ceased. Both the hand and the foot now came under the critical supervision of the eye. The eye was able to hold in plain view the performances of the hands and hand-like feet. It could see and direct their movements. It could single them out individually or watch them while they all worked together. It could even make critical discriminations in each hand and in each foot. It could select a thumb or a great toe, or each one of the other fingers and toes, and thus guide its movements. This selective discrimination in the hands and feet was an advantage never enjoyed by any of the pawed animals whose habit it is to use all of the digits together. In this manner both hand and foot profited by their new adjustments. As instruments they were capable of a far wider range of application, although it was not alone by this expansion in their utility that they became more effective. They were better agents for sensing the world and possessed a more ample sensory capacity which arose from their own multiplied movements.

Threshold of a Great Change

In the animal kingdom it would be difficult to find more provocative influences than those which determined the transformation of paws into four hands. Considered casually, the appearance of the quadrumanous monkeys in all their varieties seems little more than the addition of many interesting forms of life. This addition, however, had a far greater significance. The four-handed stage of animal existence led to the highest development of the brain. Without this stage the ultimate advances in life, the supreme achievements in progress, would have been impossible. Numerous factors contributed to the acquisition of hands and hand-like feet, but no one of them was more potent in the final outcome than the effects of tree-living. Almost every other combination of habitat and adjustment had exerted its influence upon the form of the mammalian body, yet in no other instance has there been achieved a success comparable to the development of hands. Most mammals are equipped with highly efficient eyes, keen ears, and a serviceable sense of smell. These endowments have had opportunity to contribute to the efficiency of life. But neither sight nor hearing nor smell was sufficient of itself to determine those advantages capable of giving the animal a supreme position. It was the hand which opened the door to give the senses those opportunities never enjoyed before. It called upon the brain for further expansions to direct new ranges of movement. It required additional brain extensions for a greatly amplified sense of touch in the fingers and palms, in the toes and soles of the feet. It was the hand, in a word, that afforded an entirely new grasp upon life and in the end created not only a new order of mammals but almost a new kingdom of life. The transition from paws to the hands of the quadrumana is the threshold of an epochal change. As the paw was the basic pattern for the hand, the hand was the indispensable stepping-stone to the development of man. This formula may perhaps seem altogether too simple and graphic. It would be such, in fact, if many of the important intermediate stages in the process of development were overlooked. These stages may now be considered.

The consequences of the transition produced under the influence of tree-living appear conspicuously in the lengthening of the digits to form fingers, in the appearance of an opposable thumb, in the acquisition of a grasping hand. All of these are definitely adaptive changes. They are applied directly to meet the conditions of locomotion through the trees. But if these modifications conferred upon the animals many real advantages, they also introduced certain imposing hazards to further progress. They were adequate for the mastery of arboreal life, yet at the same time they permitted the forest to become master of these four-handed animals. This is true in exactly the same way that the sea imposes its laws upon aquatic mammals, the plains dictate to the ungulates, and the air exerts its control over the bats.

Possession of too Many Hands

So far as the monkeys are concerned, an obstacle lies squarely across the path of further progress. They are possessed of too many hands. Hand and hand-like foot both serve the purposes of locomotion. Neither the one nor the other is afforded those opportunities of exclusive use which are essential to the highest development. This is true even of most of the monkeys of the Old World, like the macaques. Their locomotion requires the use of all four extremities. They run along on the top of the branches, grasping firmly as they go. They leap from one branch to another, employing all four hands in this mode of transportation. As a result of these activities the hands are long and slender, the fingers long and tapering, and the thumb short but opposable. The foot has much the appearance of the hand.

One group of the ape world offers a striking departure from this more general rule of development. This exception is particularly interesting. It appears in the baboon and more especially those members of their family which have taken up a life upon the ground. With the baboons the resumption of terrestrial life came long before any of the monkeys had made pronounced advances toward the erect posture. It is for this reason that when these animals adopted habits of ground life they readjusted themselves after the fashion of other four-legged animals. They travel about much like the dog or cat, with their muzzles directed to the earth. In fact, many of their features, both in head and body, take on a definite canine appearance. A feature of special significance is the manner in which their fore and hind limbs have reacted to the influences of ground-living. The great lengthening in the hands, fingers, feet, and toes, conspicuous in monkeys that live in the trees, has actually been reversed in the baboon. It is still proper to speak of hands and feet, but both hand and foot have shown striking tendency to revert to paws. This specialization illustrates a remarkable disgression in the development of the monkey kind. It means, if it means anything at all, that the adaptations necessary for carrying on life in the trees have withdrawn their influence and permitted the habits of adjustment to the ground to modify the character of the extremities. In four particulars the hand of the baboon shows distinct tendencies to revert to a paw:

1. All of the fingers are shortened.
2. The thumb has been reduced if not to the state of a vestigial tubercle as in the dog, at least until it has become extremely rudimentary.
3. The nails have become much longer and more slender, as if they were tending to form claws.
4. Both the tip pads and the palm pads have become more prominent, the latter actually fusing to form a single palmar cushion.

In the foot similar tendencies toward a paw are present. The lesser toes and the great toe are much shortened, and there is a distinct fusion of the plantar pads. This reversion in the hands and feet of the baboon shows clearly how readjustment occurred when the influences of tree living were withdrawn. It also demonstrates the strong tendency for the chirideal structures to assume the ancient patterns of the paw in response to the habits of four-footed living upon the ground. The baboons, therefore, cannot be considered in the direct line of progress. They not only failed to advance the cause of developing the hand but they did nothing to further the erect posture or the progressive expansion of the brain. It was perhaps the large size of their body that made it necessary for them to desert the tree and seek more secure support upon the ground. This increase of body size, however, came at an early period, long before the primates had begun to feel those decisive influences which favoured standing erect.

Brachiation and the Erect Posture

Considerably later in geologic times another class of apes made its appearance, which felt the full power of this determining influence. These animals were the gibbons. They introduced a new type of transportation. Their locomotion no longer depended upon running along on the tops of the branches, or leaping from one support to the next. They introduced the novel method of swinging by the hands. Reaching for a branch over the head with the right hand, the gibbon swings its body forward to grasp the next branch in advance with the left hand. Swinging in this manner, step by step, first with the right hand, then with the left, these animals walk through the trees. The results of this arm-swinging locomotion (brachiation) are apparent in the development of the hand. The fingers, tip pads, the palm, and the palm pads are greatly elongated. Similar lengthening is also apparent in the forearm. The acrobatic manœuvring requisite to such locomotion has developed a high degree of skill in using the hands and arms. It also requires a close coöperation between the movements of the upper extremities, eyes, and head. The influence of these several modifications has impressed itself upon the brain. But the most decisive effect of the gibbon mode of locomotion is seen in the posture of the body. The swinging by the hands well above the head produces an almost constant erect posture. The muzzle no longer points, as in the great majority of monkeys, toward the ground. It, as well as the eyes, is now directed toward the horizon, and thus those factors which have contributed most to an upstanding, forward-looking primate were first introduced by the gibbon. The foot of these animals, while it retains many features and markings of a hand, affords a fairly satisfactory support for bipedal locomotion in the erect posture. Obviously the effects of tree life are responsible for these changes in the gibbon. All other monkeys up to this stage have been embarrassed by an over-endowment of hands. But the gibbon, by over-emphasizing the upper extremity, has to some degree nullified the importance of hand-like feet. It has begun the solution of that perplexing problem which was imposed upon the monkeys by their almost exclusive tree life and which must be solved in order to provide for the manlike specializations essential to bipedal locomotion.

In this gibbon level of the ape world such specializations began to manifest themselves. From some gibbon-like progenitor, early in the Age of Mammals, there arose a common stock capable of producing all of the modern gibbons, the great anthropoid apes, and man himself. This gibbon stage of development contained the potential material from which to evolve the erect posture, bipedal locomotion, hands freed for the purposes of the greatest utility, and a brain adequate to the needs of the highest primates.

A New Grasp on Life

In the three great anthropoids, orang-outang, chimpanzee, and gorilla, the hand is approaching more closely to the human pattern. In all three the leading advance is due to the development of a more effective opposable thumb. The result of this change has caused the disappearance of the two wrist pads so characteristic of the mammalian paw and so prominent in the great majority of monkeys. Power to oppose the thumb against each one of the fingers separately has increased to a great extent. The opponens muscle of the thumb has become more prominent and caused the appearance of a conspicuous muscular swelling in the palm of the hand, the thenar eminence. The palm muscles developed in connection with the little finger have likewise occasioned the appearance of the hypothenar eminence and at the same time the disappearance of the second wrist pad. These developments, all clearly seen in the anthropoid apes, and most prominent in the gorilla, reach their greatest proportions in man. They are evidence not of the further adaptation of the hand to locomotion but of its liberation for other and more constructive purposes.

The effects of this advance in the hand from one primarily intended to provide a firm grip upon the limbs of trees to one of almost universal application are revealed by alterations in the palmar lines. These lines are three in number, namely, the anterior, middle, and posterior groove. In the gibbon they extend across the palm almost parallel to each other. They are creases which represent the lines of palmar flexion resulting from grasping cylindrical branches. In the orang-outang these lines are still essentially parallel, indicating a hand designed to grasp a cylinder. In the chimpanzee and gorilla the palmar grooves begin to converge toward the space between the index finger and thumb. In man this convergence is complete, due to the development of the powerful hand muscle which permits the opposable thumb to reach the other fingers. This progressive convergence of the palmar lines indicates the development of a hand no longer intended for the simple purpose of grasping a cylinder, but not constructed to take firm hold upon a sphere. Figuratively this change in hand from cylinder- to sphere-holding capacity is illustrative of actual development in the intellectual grasping powers that became the distinguishing feature of mankind.

A Firm Foundation for Humanity

Thus far we have been able to trace the stages by which the hand developed in consequence of tree life. It is now necessary to follow the modifications which terminated this arboreal domination and consequently liberated the animal from the forest. This transition determined an adjustment to life that was finally productive of the most effective behaviour. The outcome of this modification was the freeing of the hand for purposes other than locomotion. The immediate agent that made such a result possible was the development of a foot capable of supporting the upright posture. This foot, as it made its appearance in man, passed through a long series of transitional phases. It had its beginning in a definitely prehensile stage when in the earliest of the monkey kind it was hand-like in its appearance. The structure that was the forerunner of the human foot had the same bones, the same muscles, the same ligaments. The only substantial difference was in the form and arrangement of these parts. Even in such a minute particular as the three contravehent muscles in the sole of the monkey's foot, which draw together the heads of the metatarsal bones, the correspondence is complete. These muscles are present and active in the gibbon. They are much diminished in the chimpanzee. In the orang and the gorilla they are still further reduced and closely resemble the atrophic fibrous strands found in man. A similar correspondence involves the muscles which separate and draw the toes together (the interossei). They are deeply situated in the plantar surface of the foot in most monkeys. In the orang and gorilla they have exactly the same position and relations as in man. The human embryo affords the final connecting link, for in this stage of development the muscles correspond to those of the lower monkeys.

The human foot is foreshadowed by that of the great anthropoids. It is, in fact, the culminating stage in that series which had almost reached the human goal in the orang, chimpanzee, and gorilla. The plantar grooves in the feet of the anthropoid apes clearly indicate the lines of flexion adapting the foot for purposes of grasping the limbs of the trees. In passing from the gibbon to the orang and the chimpanzee, with the slow development of semiterrestrial life, there is a progressive disappearance of the plantar grooves. This change illustrates the manner in which the foot became adapted to the purposes of bipedal locomotion. Of all the great apes, the gorilla makes the nearest approach to the human foot. The toes have become shorter and have lost their finger-like resemblances. The great toe has become larger and is partially assuming an axis in parallel with the other toes. It has also migrated toward the end of the foot and, in older adults, has lost much of its prehensile character. Another modification is the gradual broadening of the heel and the appearance of the plantar arch. All of these changes have been developed for the purposes of bipedal locomotion and the erect posture. In consequence of these new functions the simple grasping foot of the monkey is altered to serve as a powerful stepping lever. In its simian form the foot is a Y-shaped prehensile organ. The stem of the Y is represented by the long heel. The two branches are formed by the great toe and the lesser digits respectively. In the higher primates, such as the orang, chimpanzee, and gorilla, the simple Y foot has undergone a striking change. The sole of the foot, including the ball and the heel, has greatly increased, while the toes or grasping elements have become shorter. In gorilla this is particularly true of all the toes except the great toe, which has not only become somewhat longer but now tends to be in the main axis of the foot.

The most important features in the development of the foot are the increase in the supporting surface of the heel and the appearance of the plantar arch. In the lower monkeys the arch of the foot is double. In the great apes, more especially in gorilla, the plantar arch is single and corresponds practically to that of the human foot. The sole pads have become fused to form the ball of the foot, while the development of the heel has caused the disappearance of the ankle pads.

Whatever may have been the influences which caused certain members of the prehuman stock to desert the trees and live upon the ground, it is clear that one most important result of this change was the formation of the human foot. This structure was a solid foundation for the highest achievements of organic evolution. It ultimately produced an animal capable of dominating the world. It was responsible for all of the extensive changes incident to the erect posture—for the rearrangement in the shape of the body, for the squaring of the shoulders and the broadening of the pelvis, for readjustments in the position of the heart and lungs, for new provisions in supporting the abdominal organs, for a reordering in the relation of the eyes to provide for binocular, stereoscopic vision, for the modifications in the neck to suit the purposes of the most effective head movements, for the freeing of the hands so that they might become constructive agents, and, above all, for impressing upon brain structure the effects of these many progressive advantages. If there could be any doubt that the hand and the foot contributed in this decisive manner to the development of the brain, we might test this supposition by a pertinent question: What, for example, would the brain have been if neither hand nor foot had made its appearance? It is clear to us what limited advantages were acquired by animals equipped with hoofs or paws or flippers or wings. The brain responded to the requirements of these specialized organs. None the less, such response was always and unmistakably the brain of an ungulate or of a meat-eater, of a flying or of a swimming mammal. It was the brain of a creature of restricted behaviour, as limited in the development of its intelligence as it was in the amplitude of its adjustment to life. It was particularly deficient in one great department which is the hallmark of all animals possessing hands. Summarized as briefly as possible, it may be said that what the brain owes to the hand and foot is the frontal lobe. Through all the stages of progress, from the time when the monkeys first began to live in the trees until their successors, through graded intermediate phases, developed the hand and foot of man, this lobe has been the outstanding feature of the brain.

It is perhaps unwise and also unwarranted to speak of the debt that one organ owes to others, especially when the activities of all represent a unified process. Brain, hand, and foot are in the strict sense a single functional unit. Each is indispensable to the others. Yet it may be assumed that it was the new opportunities for action provided by the hand and foot which at length gave the brain its human capacities. These ultimate instruments of man's success amplified brain power and increased its sphere of influence. The hand in particular was the instigator, if not the originator, of human speech. Herbert Spencer, in his essay on "The Philosophy of Style," clearly points out the fundamental relation of the hand to speech, in the following words: "To say 'leave the room,' is less expressive than to point to the door. Placing a finger on the lips is more forcible than whispering 'Do not speak.' A beck of the hand is better than 'Come here.'" As the creator of indicative gesture the hand laid the foundations for the use of symbols, which, when vocalized, became established as language. This attainment was the most important single step in the ascent leading to humanity.

CHAPTER XIII

ESTIMATES AND VALUES

ASSETS AND LIABILITIES OF THE HUMAN BRAIN

THERE is substantial evidence to prove that the brain passed through many intermediate stages before it acquired sufficient power to enter upon the latest stage of its progress. Wherever it has come down into modern times, regardless of race or climate, it bears marked similarities in its external appearance. In spite of this strong family likeness, however, there are many individual variations. Some of these variations are especially noteworthy. Certain of them are of utmost importance because it is possible to discover in them the secret of man's highest achievements.

In the average human brain, as in these notable exceptions, the principle of development remains unchanged. Expansion, the root and base of this principle, has been most pronounced in the departments capable of creating human supremacy. From order to order among the mammals, increase in the size of the brain has been prominent. Depending upon the specialization of the animal, this increase has affected the area of vision, of hearing, of body sense, of taste, or of smell. Only in the family of man has this expansion made itself preëminent in the frontal region. Frontal growth is the dominant character of man's physical endowment. It seems reasonable, therefore, to speak of the entire period of human existence as the Age of the Frontal Lobe.

The Frontal Lobe and the Expansion of Consciousness

Selective development in the brain has had far-reaching effects. It has provided for special adaptability. It has furnished one or more of the senses with a particular degree of keenness. It has determined the specific lines of reaction. These lines in all animal life express themselves in three phases: (1) the approaching phase, (2) the avoiding phase, and (3) the resting phase. In the vertebrates each phase depends upon impulses which influence the nervous system, particularly the brain. The approaching reactions embrace all efforts made by the animal to reach out and acquire what it needs. In these reactions the hunger impulse is the most primitive and the most important. It arises from the necessity for food and depends upon stimuli from the entire body, more especially from the gastro-intestinal tract. Another series of approaching reactions takes origin in the herding impulse, which leads to the gregarious association of animals of the same kind, such as schools of fish, flocks of birds, herds of cattle. The stimuli for this impulse come through the contact-receiving organs. Many approaching reactions express the essential necessity of the muscles to contract, as in activities without any other apparent objective. Still more conspicuous are the approaching reactions caused by the mating impulses which arise from sexual stimuli.

Impulses of each variety motivating these reactions of approach ascend higher in consciousness, or acquire greater clarity, in direct proportion to the brain capacity of the animal. Consciousness in fish is of a relatively low grade. It becomes progressively more extensive in amphibians, reptiles, birds, and mammals, reaching its highest development in the human cortex. The frontal lobe in man provides for an incalculable expansion of these impulses in conscious clarity.

The avoiding reactions of animal life likewise depend upon fundamental impulses whose essential stimuli arise from the hurt or painful elements in sensation. All extremes of sensory stimulation may contribute to impulses underlying the avoiding reactions. They form the natural armament of protection upon which the animal depends in adjusting itself to its surroundings. As in the case of the approaching reactions, so the impulses necessary to avoidance are progressively expanded through the vertebrates until they reach their highest clarity in the human brain. The resting phase depends upon impulses derived from the entire metabolism of the body.

These fundamental impulses which become clearer in consciousness through the progressive stages of the animal kingdom tend to interact in their correlations and determine combinations of great importance. Avoiding impulses of a protective nature may combine with approaching impulses to determine a reaction of attack in order to save the animal from some threatening enemy. Thus a protective effort may be a combination of an avoiding and an attacking attitude at the same time, as when the mongoose, jumping backward in retreat from the striking cobra, still maintains the pose of attack in the entire set of its body. The resting phase may be employed as camouflage for an avoiding reaction in what is commonly known as "playing 'possum," or it may be used as a decoy in preparation for aggressive activities of attack, particularly as seen in the cat family. In man the range of these combinations has attained the highest degree of development. The frontal lobe furnishes an extensive equipment for this purpose. In all modern races frontal capacity manifests but little difference. It therefore seems clear that this common denominator of human success has given man his power to hold his place in nature and to overcome the difficulties which have beset his path.

Caucasian Supremacy

The greater apparent successes of the white race might presuppose a greater degree of brain capacity and hence a better frontal lobe. But the frontal superiority of the Caucasian peoples, if it exists, is at best slight. The white man's supremacy must, however, depend upon some actual advantage. Although outnumbered two to one, he is to-day the overlord of the world. Of the 1,700,000,000 human beings now living, only 550,000,000 are Caucasians. The remaining 1,150,000,000 belong to the yellow, black, and red races. In spite of this disparity, the white man's policies, his products, his projects, penetrate into every angle of the earth whose climate, fertility, or hidden wealth may be exploited by resources of the Caucasian brain.

Numerous facts indicate that in the white race there has been an unusually large number of individuals with exceptional brain development. Many Caucasians who have distinguished themselves intellectually show conspicuous advantages in cerebral development, especially in the richness of convolutions and fissures. The region of the brain showing this richness particularly is the frontal lobe.

Brains of Modern Races

This lobe is much the same in all modern races of men. The Eskimo brain, however, possesses frontal convolutions which are rather more complex and tortuous than in the average whites (Hrdlicka). As a whole, the brain of this northern race is heavier and larger than the Caucasian. Its excess of weight over the average white man, according to many observers, amounts to about 150 grams. The large Eskimo brain is not out of proportion with the fact that these people are compelled to contend with an exacting environment and require much ingenuity to maintain themselves.

The brains of the aborigines in Andaman and Nicobar Islands weigh somewhat less than the average white brain. The brain is broad and short; the frontal lobes are a little less massive than in the Caucasian.

The fissures and convolutions are, if anything, slightly less complex than in the white man, although the difference is not striking (E. A. Spitzka).

The negro brain, for the most part, has the same outline as the European brain (Tiedemann). The length and height of the hemispheres do not differ visibly, and their breadth is only a little less. The convolutions are large in the frontal regions and the sulci show a greater degree of symmetry than is usually found in European brains.

Among the American Indians the average weight of the brain is somewhat less than the Caucasian (H. B. Ferris). This is true both of the North and South American Indian. On the other hand, the fissures and convolutions, especially in the frontal region, correspond very closely in complexity and dimension to those of the white man.

Examination of Mongolian brains shows that the average weight of the Chinese brain is slightly less than that of the Caucasian (Kurz). The Chinese brain is said to have a number of striking peculiarities in which it differs from the brain of other races. One investigator mentions thirty-three peculiarities of this kind, and yet when each peculiarity is considered individually its prototype may be found in an extensive group study of Caucasian brains. The frontal lobe is richly convoluted and fissured. Kappers believes that the Chinese brain retains a degree of infantilism, much of which is shown in the high arching of the corpus callosum.

Accepting all of these differences in the several races of living men as to weight, dimension, development of lobes, richness of convolutions and fissures, and peculiarities in individual details, it becomes clear that such differences as do exist are slight enough to be well within the range of individual variation. In other words, when large numbers of brains of the several races of modern men are compared, the differences between them are almost certain to assume no great importance. We may conclude that the Caucasian, Negroid, Mongolian, and all other forms of the modern brain present a striking similarity in their general appearance and characters.

Brains of Distinguished Men

When, however, we consider the brains of distinguished members of the white race, we at once obtain the impression of striking individual variations. The brains of many men of genius have been carefully studied. Spitzka has collected the records of one hundred such individuals to which he has added his own studies upon six distinguished scientists. All tell the same story. These men, noted as jurists, scientists, mathematicians, composers, dramatists, physicians, journalists, statesmen, and historians, have with few exceptions possessed brains which in weight exceed those of the rank and file of the race. This is true of the brain of such outstanding men as Beethoven, Cuvier, Turgenev, Daniel Webster, Lenin, Thackeray, Joseph Leidy, William Pepper, Edward Cope, and many others. The brain of the remarkable deaf, dumb, and blind girl, Laura Bridgman, has been carefully studied by Dr. Donaldson. It is notable that in this instance the frontal lobes, both in size and in the richness of the convolutions and fissures, were well developed. It was in this region that the brains of the distinguished contributors to human progress already mentioned showed their greatest degree of expansion. Recently reports on the brains of Sir William Osler, of Dr. G. Stanley Hall, and of Dr. E. E. Southard have been published. In each of these remarkable men the size of the brain and the unusual development of the frontal lobe have been striking features. The brain of the great German historian, Theodore Mommsen, was particularly notable because of its frontal development, and so also was that of William Bunsen, the scientist and discoverer.

In contrast to the massive brains of these other men of genius, there has recently been brought to light the fact that the brain of a great modern master of literature, Anatole France, was remarkably small, weighing only 1017 grams. This weight is considerably below the average for the white race (1300–1400 grams) and not much above the estimated weight of *Pithecanthropus erectus*, the Java ape man. The difference between the weight of Anatole France's brain and that of the ape man is 77 grams, according to the estimated values. Sir Arthur Keith maintains that in spite of this noted academician's reputation, known the world over for his writings as a novelist, philosopher, and savant, Anatole France was actually an extremely primitive man. This position taken by Keith would be difficult to support against the prevailing opinions of the day. We should be more impressed by the degree of richness in development of the frontal lobe and the complexity of its convolutions and fissures than by the actual size of the brain. It would seem most likely that a marked degree of frontal development has been the decisive factor in the production of the exceptional brain. Most of the great men who have left records in respect to their cerebral endowment confirm Sir Arthur's contention that a powerful brain is a large brain. Individual variation may account for much, however, and a high grade of frontal convolution, implying as it does a great cell richness in a cortex, may make amends for many ounces of weight deficiency. From the facts available it is clear that human greatness in the main depends upon largeness of brain and extensive frontal development. The possessors of such brains have been the leaders in the activities of the white man, in every line of his progress, in every detail of his success. They have been the Caucasian thinkers, the idealists, the philosophers, the poets and artists; they have been the white man's pragmatists, his statesmen and builders of empire. They have also been his spiritual pioneers, the founders of his religions and ethics. To them has been given exceptional power of vision, with equally great capacities for transforming what such vision revealed into benefits for their race.

Caucasian Leaders

History gives them their proper places. Their dynamic personalities have touched the earth and made it bring forth its seven wonders and an increasing multitude of lesser wonders, each a marvel of human ingenuity. As they touched the earth and made it produce, so they have touched the hearts and imaginations of their fellow men until their minds responded to new aspirations and nobler purposes, until the mark of the beast was left farther in the distance and the ascendancy of mankind became the most stirring theme of creation.

History also shows how these favoured elements of the race, under the guidance of their leaders, have built brilliant civilizations, compelling systems of religion, far-reaching codes of ethics. Nations have risen, articulating the ideals of peoples scattered over vast territories. Cities have come into existence filled with the treasures of man's imagination. The same aspiration shone through them all. It was the spirit, the determination to reach out where man had never reached before.

Whatever were his material successes, still more important was that inner possession which came to man during his adventurous development of civilization. However simple it may have been in the beginning, it grew rapidly. This priceless possession was the human intellect. In many tribes of men it manifested none of the expansion discernible in the more progressive races. But with its fullest opportunity, especially under the conditions of European environment, it developed to the degree which created a new humanity. Man recognized his interdependence with his fellow beings. His social qualities now began to bear fruit in a new soil and in a more invigorating atmosphere. The finer traits of his social nature grew abundantly. Broader conceptions of responsibility to others, deeper understandings of sympathy, led to new products of generosity and new vocations of social devotion. All of the higher sentiments found easier means of expression. These were new conceptions denied to lower animals and to the lower races of man.

Scarcely less substantial than the satisfaction derived from this deep social sentiment was the gratification obtained from an appreciation of the beauties of nature and from man's own efforts to duplicate these beauties in his art and literature. But his eyes have never contented themselves with earthly attractiveness alone. When he had possessed the earth he must still reach out in imagination to gain for himself the assurance of kingdoms beyond his present state. In all his civilized period and even long before man has peered acquisitively into the unknown, to create for himself a future existence or the hope of such existence. This yearning for another and an immortal life has been the basis of his many religious beliefs. From this theme of religion have grown the impulses for the best of human achievements. It has not merely formed a halo about civilization, but has reached far inward to exert control over almost every human relation. No influence has been a greater force in the ennoblement of life. No creation of the brain has been a more effective guide in directing human destiny. No incentive has sustained human hope more consistently than the solace arising from this deep source of faith.

Age of the Frontal Lobe

The frontal lobe, which has guaranteed such advantages to man, brought him his spiritual understanding, his social attributes, and his satisfactions from art and literature. It created the means for him to gain a more adequate knowledge of the world in which he lived and of the great cosmos of which his world is but a part. The conquest of reality, the deeper appreciation of things as they are, the broad expansion of his knowledge of all things in and about him, have contributed deep satisfactions to human life. It is difficult to estimate in this day the value of all the great contributions to science. It is difficult also to state which product of man's frontal lobe, his social development, his religion, his art, his literature, or his science, has meant most to the growth of that imposing figure in which he now presents himself. No one of these elements may justly deserve to be set above the others. Deprived of any of them, the race might have been seriously impoverished; it might never have attained that position which entitles it to be considered the supreme achievement of creation. It is little wonder that the gods which man set up for himself have been anthropomorphic, cast in his own image and likeness.

In later days there were reasons for the Caucasian's assurance, for his self-reliance, for his faith in his own judgment and reason. Peace and comity existed between the nations of the earth. Prosperity was within their borders. Success and progress filled every walk of life. Social order rested upon firm moral foundations. This was a human establishment upon which to depend. But ultimately this record of the white man, from the beginning of his civilized period down to the early decades of the Twentieth Century, brings us to a fateful midsummer day, the 1st of August, 1914.

Old Sores and Liabilities

Perhaps there are no good reasons for turning back to such old sores. Can any conceivable advantage come of opening again those vaults holding that which we would rather forget? With passing years memory gradually relinquishes what should be the immortal lessons of experience. The horror, the degradation, and all other outgrowths of the protective mechanisms making for better judgment, for saner living, for wiser avoidance, are soon forgotten. We look and see only the whited sepulchre. The dissolution and disease, the lurking danger for the future, are concealed. Yet these are our liabilities. If we drive on blindly or with our eyes closed to them, such prosperity as we have attained is destined to disintegrate.

It is the old formula over again that we see beginning to reproduce itself on that fateful August afternoon. The expansive demand for power, the will to dominate, the insatiable determination to possess, are all disdainfully snapping their fingers in disregard of the rights and peaceful pursuits of others. Sacred obligations are thrown to the winds with the crackling of a scrap of paper. There are no obligations. Lust, greed, and the dregs of human cruelty are seething in the breasts of men turned animals, are ready to speak with the tongues of every manner of ruthless torment. By armies men return to the filth of the earth, living in the mire, breathing the stenches of their own corruption, inhaling the gases of sadistic invention, meeting the flame of an earthly purgatory, and inspired by the single indefatigable impulse to kill. And for what purpose? None but the old one! To grasp, to gain, to seize by force! There is no question of right or wrong. The only question is right of possession. Both those who attack and those who defend pray to the same God and pray the same prayer.

Here in our own days is the frontal lobe leading a great fraction of the white race not merely into hell but to the brink of its own undoing. If it failed in this leadership it was by the narrowest margin. It has left us still gasping on the edge of the precipice into whose depths we have gazed, wondering how long ere we see them again.

Courage, endurance, and heroic determination we say were the compensating atonements for this madness, for this maniacal era of wanton destruction. Nobility of purpose rang out in the defiance—"They shall not pass!" Yet where was the nobility in that machine-made death which swept regiment after regiment into oblivion by its withering fire? Who now will claim the glory of 400,000 dead in less than a lunar month, of 8,543,515 fighting men fallen in the early prime of manhood in four years of war? Is this the chronicle for a great race to glory in? It is rather the record of the white man at his lowest ebb, dehumanized for a mere bauble of possession.

Thus, through four brief years, out of the unhallowed precincts of no man's land, the mark of the beast came back. The white man learned that the cloak over his baser passions was a thin veneer. He learned, or may have learned if there has yet been time to recover from the overwhelming concussion, that he is not yet master of himself, that the chief guide of his life may on slight provocation lead him not rightly or well, but with unerring precision, into the pitfalls of extermination.

When the Pressure Comes

We speak of loyalties and vocations of devotion. Where are these when the pressure comes? Where are they when the man stands with his mob? The greatest and best things in life at once take flight. There is not even standing-room for them when hate and revenge are the passions of the day. It is then that class stands against class. All that wealth and culture and luxury have built through centuries finds no strength against the ire galvanized by equal centuries of oppression. Those who have suffered their silent agonies confront those who are about to die. Such have been the tragedies of revolution. So it was in the French Revolution, with its history of guillotine horrors. Such was the case of Russia in revolt. Such it has always been wherever the privilege to enjoy, concentrated for the benefit of the few, has worked disadvantage to the many. Neither those who for the time enjoy, nor those who are deprived, have sufficently learned the lessons of moderation, self-restraint, and control over the human spirit to hold in check the baser impulses.

War, revolution, and other mass reactions in the interest of readjusting man's social conditions are not rare in our racial experience. Since the beginning of historic times there have been thousands of wars of greater or less magnitude. If, during the Roman era, the gates in the temple of Janus stood open for centuries and that great people were almost continuously at war without appreciable cessation, we moderns would have no need for an energetic gatekeeper. In one place or another, throughout the globe, we have been continuously waging war or producing revolutions. Following the close of the great World War, a little more than a decade ago, there have been no less than sixteen wars, and seventy-five thousand men have died as a result of warfare. Let those who philosophize in security call war an activity essential to human progress. Those who know it through suffering and loss will call it by its proper name. It is not, however, in war alone that we may discern the results of our defective control over human nature. We need turn but a few pages of history to encounter many other sore spots. Among these blemishes are those arising from a source which should have been our most unfailing, our deepest consolation.

Heresy and Retaliation

The spiritual heritage bequeathed by the Great Galilean retained its influence for little more than two centuries. Through the dark Middle Ages Christianity wandered far from the path of its appointed blessedness. To many it ceased altogether to be a blessing, and to many others it became an actual curse, meaning for them torture, imprisonment, starvation, humiliation, or death by burning at the stake. There can be little wonder that heresies sprang up against the inhuman conduct of the mediæval Church. Corruption, discrimination, demoralization, abuse, and tyranny went unrebuked. The church militant was infected by every sin that it was created to prevent. Heresy was the reaction to such corruption, and the Inquisition was the retaliation on the part of the Church to preserve itself against heretical disintegration. The barbarous zeal which through many centuries brought misery to mankind in the name of Christ has been explained in several ways. Some have denounced it as mere bloodthirstiness or lust of power. Some have traced it to the doctrine of exclusive salvation. In order to understand it properly we must comprehend the stage of civilization in which it flourished. The feudal military spirit was everywhere dominant. Society relied more upon force than upon persuasion. Industrial influences had not yet tempered modes of thought and action. Throughout the Middle

Ages men were strangely pitiless in their dealings with each other. The wheel, the cauldron of boiling oil, burning alive, burying alive, flaying alive, and tearing apart with wild horses were the ordinary means by which jurists endeavoured to deter crime. In England poisoners were boiled to death as late as 1542 (Rouse and Margaret Davie). One woman, in 1726, was burned at Tyburn. Minor crimes were dealt with with a harshness unbelievable in this day, including such hideous procedures as blinding, mutilation, tearing with hot pincers, breaking on the wheel, and cutting out the tongue. People of all nations were accustomed to this cruel savagery and accepted it in relation to crimes that were thus punished. By popular detestation heresy was regarded not merely as a sin but as the worst of all crimes. This belief was held with equal tenacity both by the clergy and the laity. Under the influence of such feelings the Church adopted the harshest measures and continued to grow more cruel and more unchristian.

The Inquisition was not a local phenomenon. It became most intense in Italy, where it gradually took shape. In time it spread into Germany, into France, and into Spain. The Spanish Inquisition was employed for the most part as a state institution to maintain the throne. It used all of the ingenuity known to the ecclesiastical inquisitors and added punishments of its own. The torture chamber, which at first was not introduced as an inquisitorial instrument, soon established itself as an indispensable accessory and flourished in many parts of Europe. There was a furtiveness in the manner in which the Church doled out these punishments. For the repentant heretic life imprisonment on bread and water and in chains was not a criminal sentence; it was the means of repentance and salvation for the unfortunate sinner. If the heretic remained unrepentant the Church washed its hands of him as a capital offender and turned him over to the secular authorities to be burned at the stake. The dungeon in which the unfortunate victim was imprisoned for life was a frightful chamber, damp, and infested by rats and vermin. Confinement was solitary and various circumstances besides pain and hunger were brought to bear upon the terrorized imagination of the prisoner. These dungeons were often ingenious means of torture. One in the Bastille at Paris had a floor which was conical and pointed downward so that it was impossible to sit or lie in it. Another in the Châtelet had a floor continually covered by water, compelling the prisoner to stand erect. Persons convicted of heresy were also forced to wear crosses of cloth, generally yellow, sewed upon their garments. In this manner the symbol of Christian devotion was converted into a badge of utmost shame. Confiscation was another penalty with frightful effects. Upon arrest for heresy a man's property was sequestrated, and his family thrown into the street. After several centuries of unremitting cruelty the Inquisition succeeded in suppressing the various sects of heretics. For this advantage the Christian Church paid an unnecessarily high price by gaining for itself a lasting stigma.

Provocations of Circumstance and Time

Such interludes as these in the course of man's happiness and peace may perhaps be regarded as unfortunate digressions from the scheme of human behaviour. Their apology lies in the fact that they belong to other times by contrast with which we have shown great improvement. We are much changed for the better—so much changed that many of these appalling episodes of history could not occur in this day. Reassurance of this kind may comfort us, but it does not provide us with protection against ourselves. For with due provocations of circumstance and time there is no guarantee that we would not repeat or even amplify the ghastly delinquencies of the past. The pride we feel in our modern progress and prosperity elevates us to a plane of conscious superiority. And yet this same pride experienced a sickening collapse when no later than our own day and generation it was forced to witness a phenomenon of eruptive brutality compared to which all former warfare was insignificant. In spite of this recent experience we feel sure of ourselves, confident in the great capacities which have made us men. We possess this confidence, however unenlightened we may be concerning the real power upon which we depend, especially as to its source, its nature, its possibilities, and its proper management.

Compounding the Essential Impulses of Life

As no other members of the animal kingdom, we have compounded each one of the essential impulses of life. Through our frontal mechanisms we have raised these primitive drives to the most elevated planes of consciousness. We have increased their clarity to the highest degree. It was doubtless the introduction of symbols which first secured this greater clarity. Later the development of spoken language established the universal medium of exchange within the brain. Lower animals evidently do not learn to speak. They only acquire the use of beast cries by which to transmit warnings, sex invitations, or challenges to combat. Such specific cries modified by the structural adjustments of man may have been sufficient for the simple human language of earliest times. There seems to be no actual barrier between the vocal activities of birds, dogs, apes, and men except that superior mechanism of speech provided by a progressively developing frontal lobe. From its first introduction language was a societal phenomenon. All of its products were likewise societal. If it raised man as an individual, its greatest profits appeared in the elevation of the social order. Under this new influence the primitive impulses of hunger, herding, mating, avoiding, and the rest entered into complex combinations. In consequence, each primordial drive was converted into a thriving industry in the interest of further human satisfaction. Excessive growth in these industries soon manifested many dangerous tendencies. New human expansions developed out of the primitive impulse of hunger under the added opportunities of the frontal lobe. Appetite and indulgence with their tendencies toward excess came in conflict with sumptuary restrictions and prohibitions. The effects of frontal expansion upon the herding impulse contributed to the development of crime, to the creation of mass phenomena under the influence of fear, hate, and hope, to the epidemic spread of group manias and popular delusions such as were the pilgrimages, crusades, and demonism of the Middle Ages, such as was the extremity of ruthlessness manifested in the last great war. The extension of the sex impulse through the mechanisms of the frontal lobe is incalculable. From it have come crops of asceticism and licentiousness, of poetry and sentimentality, of social order and disorder, of philosophy and pure bunkum. The expansion of impulses underlying the avoiding reactions has produced an unescapable blight upon human life due to the extensive corticalization of fear. The fear of bondage or slavery, of tyranny or cruelty, is no longer upon us. A multitude of more subtle fears, engendered by modern civilization, have produced our phobias, our irresistible compulsions, and our great variety of somatic and psychic anxieties.

Human Nature Has Not Changed

The incentives of life have been magnified and multiplied upon the screen of the frontal cortex. They have afforded man his powers of judgment and reason, his greater capacities to enjoy existence, his new aspirations of hope. They have supplied him with his broader opportunities to order and adjust his life and with his stimulating inspirations of learning. Each of these new capacities is conditioned by the circumstance and fashion of a given age. There is no arguing with such fashion. The *mores* and the times, the customs and the place, dominate the products of the frontal lobe and mold them in constantly changing patterns. The fashion of yesterday is often the laughing stock of to-day as that of to-day may be the jest of to-morrow. These plastic patterns, which the frontal lobe produces for the conduct of human affairs, have neither permanency nor assured foundations. Great principles which we swear by now we know are wholly transitory. While they last certain moral notions and devices are in fashion, but these are conditioned by the times and customs. In such facts as these may be recognized the variable quality of human wisdom. Reason is likewise based upon conditioned reflexes which have grown out of the *mores* of the time and place. In this light, if man seems to have come a long distance from his early beginning, the path measured in units of real progress is surprisingly short. "Things happen," says Sumner, "which show us that human nature has not changed and that the brute in each may awake at any time. It is all a question of time, custom, and occasion and the individual is coerced to adopt the *mores* as to these matters which are then and there current."

Morals and manners, like speech, are societal adjustments. They are highly conditioned reflexes acquired through generations of social experience. Self-restraint, agreeability, and coöperation form the basic currency of successful social intercourse. They are the artifacts of group needs, the medium of exchange in all comfortable and safe contacts between man and man. That these qualities are superficially engrafted upon human nature is easily demonstrated. With adequate provocation the individual discards restraint and reveals the grossest traits of his aggressive reactions, the group is quickly resolved into the lawless mob, and nations are easily excited to martial frenzy.

What benefits, therefore, will we obtain by further self-deceptions? It is long overdue that we see through the thin fabric of traditional delusions wherewith we have surrounded ourselves. It requires courage to face the truth and an open mind to recognize it. But we cannot hope to improve unless we see ourselves as we are, unless we appreciate our inherent liabilities as well as our assets, unless, divested of angelic or godlike disguises, we stand forth for our own inspection as human animals occupying the foremost place among living things only by virtue of the best brain thus far developed. Much that is animal within us must remain unchanged despite our utmost strivings. All that is human may be modified, enhanced, and brought to better fruition.

Handicaps and Restraints

Almost from its beginning the race has recognized its handicaps. It has struggled in many ways against its own liabilities, especially those due to increased brain power. By systems of philosophy the human spirit has sought to show the reason and goal of life, has endeavoured to envisage the most desirable pathway for existence.

Man has endeavoured to hold himself in check through religion, bowing to the belief that for every human being there is some higher power controlling destiny and for this reason entitled to obedient reverence and worship. For his hour of need, however, philosophy and religion offer no reprieve. The Great War comes, and assurances from these sources of human reliance have no power to stay the catastrophe.

Man has experimented through societal organization, through the formation of governments, through the establishment of laws, to restrain the dangerous tendencies of his frontal lobe development. But if his governments succeeded in utilizing effectively his efforts at social order, they have also abused these efforts. In every societal system there must be a ruling class. According to Professor Sumner, no class can be trusted to rule society with due justice to all its members. Whatever the sins of antiquity, modern society is ruled by the middle class. It has to its credit the invention of institutions securing civil liberty and the safety of person and property. Its history is otherwise not satisfactory. It has demonstrated that in no popular government could sufficient control be created to restrain the abuses of special privilege, to avert the corruption of civic power for graft, or to repress the selfish undertakings of cliques formed on special interests for the purpose of public exploitation. When faced by this test, all modern democratic states have failed. Plutocracy and the unscrupulous powers of wealth are at the root of the financial scandal, which is the blemish upon all modern parliamentary organizations. We must recognize this defect not merely as a tendency of the times but as a national disease. It spoils every institution and, extending from one generation to the next, at length destroys in the masses the faculties of ethical judgment.

The Cult of Success

By education man has likewise endeavoured to moderate the recognized liabilities of his frontal lobe. But, like his customs, his education has varied with the fashions of his time and place. With one brilliant exception educational processes have too strictly been confined to technological training, or to the inculcation of traditional cultures or mediæval scholasticism. The ancient Greek alone dealt with his life and its problems as we well might with ours. We are imitators and large users of secondhand materials. He was an originator. His education was an adventure of discovery, an absorbing search for the understanding of what constituted the good life. Largely without traditions and upon his own initiative he endeavoured to gain a critical attitude toward all of his prejudices, to liberate himself from the dominance of herd influence, and to adjust his conduct most intelligently for the welfare of the state.

Modern education is especially in a state of confusion. It is almost wholly devoid of any broader theme than that embraced in the purpose to teach the individual the formulas necessary to make good. There is little effort to inspire a larger point of view, to instill an understanding of life's values, an appreciation of its relations, and of its truly human opportunities for intelligent living.

Philosophy, religion, societal order, government, and education have failed to produce any entirely satisfactory solution of life. They have scarcely recognized the existence of the frontal lobe, but, looking beyond it to some intangible sources of power, they have neither capitalized its assets nor reckoned with its liabilities. There is probably a cause of long standing behind these several failures. For centuries and ages the incentives of human efforts, even the best, have laboured under a contaminating influence. This influence has touched and tainted every aspect of life. During thousands of years men have struggled to make good in Europe. The result has always been the same. From time to time some section of the race has succeeded, later to weaken, and in the end to succumb. In the past an invariable cycle of rise, decline, and fall has dictated the course of life in Europe. Such was the lot of the Neanderthals. Cromagnon and Neolithic men both had their days of success and of disappearance. It was not different with the Greeks or the Romans who rose and finally, under this spell of Europe, passed into decline. In many respects the motive at work in this destructive cycle seemed to act like some evil influence. It was already well developed in the first trading exploits of the Phœnicians. With them it began to migrate westward from harbour to harbour along the Mediterranean. It implanted the germs of its spreading infection, which came to be the dominant spirit of civilization—gold and a price for everything. Nothing escaped the effects of this new standardization of human enterprise. The pioneer Phœnicians carried this gold standard of life far beyond the Pillars of Hercules to the shores of Britain until it spread throughout Europe. The source of this influence lies far back of these earlier civilizations. It had its origin in those primitive days when Mousterian cave man tasted the first drafts of power. The use of this power he justified by one standard only—success. For three hundred thousand years the human brain has been conditioned by this influence. Power increased, successes multiplied, and the passion for possession became a frenzy. Thus it was that those whom the gods would destroy they first made rich; and thus also one civilization after another met its destruction. No other solution can be worked out on this standard of existence. It will serve to exploit nature, including human nature. It may bend the natural forces one after another to man's bidding. It may make him master of the entire world except in one superlative detail—himself. In proportion as it has been concentrated upon the conquest of the earth, it has had little time for the mastery of the spirit. The old idea is still at work with us to-day. We have found nothing new, nothing better.

We scarcely attempt to look. It is now our ruling passion. It has been the contaminating influence which has for ages frustrated the best human efforts.

Wealth, with the power to confer upon the greatest number the benefits of true human satisfaction, is not to be condemned. Its acquisition and proper distribution must be intelligently encouraged. Such wealth is the just return on man's efforts to make and maintain for himself a wholesome place in nature. But riches, representing egocentric aggrandizement and the upbuilding of special privilege for selfish ends, are an open sore in all times and a most serious menace for the future.

The ancient motive of possession is still the most powerful urge among civilized peoples. It has exerted an increasingly evil influence upon modern times. Its effects have been unfavourable because possession and power depend upon the offensive and defensive mechanisms of aggression. Such mechanisms are the progenitors of war. They promote the conflicts of social rivalry between classes and incite the struggles for competitive supremacy between nations. If the goal of such life is success, the price of such success is strife. This is the standard of existence which has prevailed for at least three hundred thousand years. It seems irrevocable. Nothing visible in our modern world suggests the cessation of its destroying influence. In the absence of any present reassurance there is a strong probability that we are following, to its bitter ends, a path long familiar to our race.

CHAPTER XIV

THE FINAL TEST OF THE BRAIN

WORLD COÖPERATION AND RECIVILIZATION

OUR most vital issue is no longer a matter of national prosperity alone. The success and therefore the happiness of the entire world are at stake. This generation of ours has taught us what to expect from the old forces of competitive wealth and nationalism. It is not difficult to foresee the recurrence of one war after another. As Dr. Butler has so forcibly said: "The world is just now standing at a crossroads. It may take the path in one direction and so make agriculture, industry, commerce, trade, finance, the fortunate means of uniting the whole world, of increasing its prosperity and of buttressing its peace; or it can take the opposite path and so turn the nations into narrow-minded, unsympathetic, jealous, and quarrelling neighbours, and prepare the way for another cataclysm which, if it should come, would mark civilization's end. What are we going to do about it? Where shall our influence be thrown? Shall it be for a repetition of the old stupidities, the old ignorances and the old antagonisms, or shall it be for a new world order in which selfish competition shall be supplanted by kindly and large-minded coöperation? That is in substance the crucial question which at this moment awaits answer by leaders of opinion in every land."[1] There are many who believe that man in his present exalted phase cannot stand the test. His modern days are numbered just as surely as were those of his ancient glory. He has no further reliance, no better assurance now than he had then. The fate of civilization hangs in the balance; its chances in many respects are unpromising. There are no guarantees for the future outside of man himself. Although we have multiplied in number and compounded our problems of life, the world in which we live is much the same as it has been for hundreds of thousands of years. If man also remains unchanged we may expect the same lot which befell other successful people in the past.

And yet looking beneath the surface and into the depths of the organ which has been the chief asset of our progress, we may discern some promising possibilities. These are possibilities which if developed might subordinate or overcome the ancient lures of power and possession. They might even establish a new order of existence, a new age of wisdom, with clearer ways of looking at life and better methods for realizing its opportunities. We may have no desire to see these possibilities. We may turn from them now as we have before. They clearly exist, however, and chief among them is the possibility of a better human brain, a brain with much more ample power by means of which to create a better world.

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[1]From "The New Center of Gravity," an address delivered at the Parrish Art Museum, Southampton, L. I., on Sunday evening, September 1, 1929, by Nicholas Murray Butler.

Many facts support this possibility. We know from certain evidence that man in his earliest period on earth possessed a brain much simpler than that responsible for his modern successes. Such testimony is given by the brain cast of the Java ape man. The entire cerebral structure in this instance was in an intermediate phase of human development. It was far in advance of the brain of the highest apes but much less developed than the brain of modern men. In spite of its simplicity it gives evidence of human progress. It had supplied the structural basis needed for a crude type of humanity. It indicates that the powers of human speech had been acquired and that the first steps in the upbuilding of human intelligence had been taken.

Compared with this primitive race of extinct men, the Piltdown and Rhodesian brain casts bear signs of definite progress. With the passage of time brain power continued slowly to acquire new capacities. Nothing makes this conclusion more certain than the facts revealed by the Neanderthal casts. From them it is clear that the chief organ of life which directed the successes of the Neanderthal race had assumed many aspects of modern development. Most of this progress in the brain during its gradual stages upward, through the ape man, the Dawn man of Piltdown, the Rhodesian, and the Neanderthal, manifests its highest degree of expansion in the frontal lobe. With the coming of the Cromagnon race all of the cerebral requirements necessary to modern man made their appearance. Thus through more than a million years the brain has slowly improved. There has been a steady increase in the size and richness of its convolutions.

In contrast with the lifetime of other families in the animal kingdom the human race has scarcely passed out of its early youth. Our race seems young as the ages of the earth are estimated, and our racial youth justifies the belief that the modern brain represents some intermediate phase of ultimate development. The facts of the distant past point ahead to periods of further progress in the future. Influences which have operated through vast intervals of time in slowly advancing the brain from one stage to the next are doubtless still at work. The impulses necessary to brain development had their beginning in the fishes. They continued through reptilian and mammalian phases and finally passed into the period of tree life wherein the foundations of the human brain were laid. It is difficult to believe that this impetus of progress which persisted for ages has at length ceased to act.

The possibility of a better brain finds support in another fact of great interest. An entirely new force favourable to progressive development has made itself felt within the last century. Never before has it exerted an influence upon the process of evolution. At present it is difficult to estimate its full value as an element of progress. This new force arises from the fact that men and women throughout the world have recognized the existence of an evolutionary process. In all places where the earnest search for truth is being made this knowledge has become the dominant note. It cannot fail to lead to new understandings and to add new quota of power to the organ of our chief reliance. An adequate appreciation of the processes underlying natural selection is certain to impart new and practical significance to the survival of the fittest. The means which may subsequently be employed to further such survival cannot be predicted. Whatever they may be, if they justify themselves by advantageous results, they will be applied with courage and intelligence. They may embrace measures of extensive restriction and intensive selection to meet the conditions of overcrowding in population, and of inequality in the emoluments of life. The embarrassments of the laggard fractions of humanity would thus be overcome.

Application of wise societal regulations having as their object the better apportionment of opportunity and the greater accessibility of human happiness might easily be conceived as the outgrowths of such further extensions in knowledge. Obviously the questions concerning the character of the means directed to these desirable ends cannot now be discussed or foreseen. It is sufficient to indicate that whatever these agencies may be, provided their results are calculated to contribute to the betterment of mankind, they may be discovered and made practical. This possibility presupposes the attainment of those advantages which accrue from a better understanding of man as a participant in a still active process of evolution.

If up to this time we have employed the full power of our intelligence, if we have made the best use of the brain, there may be actual doubts concerning further progress. Many reasons justify the belief, however, that the human race has not yet utilized the brain to its fullest capacity. Numerous facts support this view and make it appear certain that we have developed but a small fraction of our potential brain power. In exceptional cases of outstanding groups and highly specialized individuals the brain may have yielded something approaching its best product. Even in cases of unusual development there are deficiencies and inequalities of development due to the circumstances of training, to the introduction of adverse influences, and to the universal lack of any generally acceptable goal of life. A cross section of any community estimated by its high and its low intellectual attainments indicates a striking unevenness in brain development. It also reveals a low rating in the average intellectual level. Averages of this kind obtained from nations or races disclose an aggregate of brain power far below the grade of the brain's potential capacity. Instances of individual specializations make the fractional development of the race still more evident. If, for example, Laura Bridgman, deprived as she was of sight, hearing, taste, and smell, with only a fifth of her brain areas accessible to satisfactory contacts with the world, made an adjustment to life equal to the average of such adjustments; if Helen Keller, almost equally deprived of sensory impression, is rated by many as belonging to the class of genius; then the rank and file of mankind uses but a small fraction of its potential brain power. This fraction has been variously estimated at one fifth or one half. It seems obvious that great advantages for the extension of intelligence might arise from the utilization of the unemployed fifty to eighty per cent. of human power. The large portion of the brain not used by the majority of mankind introduces the disquieting thought that the usual way of life is the easiest way. The intelligent way is laborious and fraught with many trials incident to arduous application. Brain capacity may be improved only by patient and continuous effort and by an unremitting submission to diligent self-discipline. The avoidance of these exactions has made the development of the brain a slow process in man. It is the general disinclination to depart from the path of least effort which has held human intelligence at its average low levels. Many factors have contributed to this attitude. Not the least among them is what may be called mixed survival. This is a provision by which not only those thoroughly equipped but those as thoroughly unfit are presumed to enjoy equal opportunity in the advantages of life. The unfit depreciate the general average. Their inclusion creates the level of mediocrity and retards the progress of the fittest.

Another fact affords hope for the further development of the unused fractions of human brain power. It is possible to demonstrate that certain structural and chemical elements in the brain develop in relation to the use made of them. This is particularly true of the insulating substance surrounding nerve fibres. Such fibres serve the purpose of impulse conduction. Simple and complex associations alike depend upon them. It has been shown that the simplest of these fibre connections come into use early in life while the most important connections appear at later periods. In order to be effective the connecting fibres must be insulated. The insulating material, a complex chemical substance, makes its appearance in direct relation to the different periods of mental development. This insulating substance is least in amount at birth. It increases noticeably at the end of the first year at about the time when speech is acquired. It shows marked additions at the seventh, tenth, and twentieth years. Thereafter it increases slowly up to the fortieth year. It also manifests the interesting phenomenon of gradual decrease in the declining years of the late decades of life. Apparently the mental development of different life periods requires differing degrees of insulation in the brain. The functional use of definite areas appears to bear a direct relation to the degree of insulation. The more areas in use, the more numerous are the insulated nerve fibres to facilitate proper operation. The child uses and needs less than the youth, and, in the general case, the youth less than the adult. The development of the brain thus appears to be proportional to the use made of it. In this way human intelligence may be gauged in terms of actual brain structure. In cases of low intelligence the demands have been relatively small, and large fractions of brain remain undeveloped because unused. Higher grades of intelligence require more extensive development because the objectives of their application are more complex and more exacting. They are the response to the more extensive utilization of brain power.

The recognition of this relation between use and structural development of the brain clearly points the way by which human intelligence may be extended. This relation has long been understood as a biological principle. It has been practically applied in the training of muscular strength and endurance, in the sharpening of the senses, in the cultivation of the voice. Its practical application to the development of the brain as a whole has been much less assiduous. Both in principle and practice this relation of use to structure indicates possibilities for producing a better human brain. The unused fractions may accordingly find opportunity for utilization.

Still another possibility for advancement arises from more adequate systems of human training. The success with which the brain is used depends in large part upon its conditioning. Such conditioning is determined by many factors. In the broadest sense it includes the influence of physical environment from the earliest moments of life, the effects of societal habits and ideals both in the family and in the group, the impress of formal education and educational forces, and the direction imparted by differing degrees of satisfaction, health, and disease. If, for example, the objective is accommodation to Arctic life, the conditioning process differs in many details from that necessary for adjustment to tropical existence. If the end sought is success according to European standards, a totally different set of conditionings is essential to this result. Civilized nations as well as barbarous tribes may be trained through generations to the pursuits and practices of warlike aggression. The results of such conditioning were clearly demonstrated in the Great War. Ultimate adjustments are thus strongly influenced by the group, the group outlook, the time, and the place. For this reason every experience in and every contact with existence assumes high value as a conditioning factor. The entire span of life, from birth to death, becomes a period of active training which may be consciously directed. The element of chief importance in this conscious control is the recognition of the end to which the training is directed. If the highest qualities of human happiness and satisfaction are the objectives, every factor which contributes to the conditioning must be carefully estimated and properly adjusted to this end. Such certainly is not the objective under the modern cult of success.

The earth, which we have made a bone of contention, might, to our infinite advantage, become the sphere of human content. In order to determine such a change it is necessary to reëstimate and readjust every influence capable of conditioning the activities of the brain. The recognition of the uninterrupted continuity in the conditioning process and its specific requirements in relation to definite phases of development is most essential. Influences of the physical environment from the first moments after birth through all successive periods demand extensive, renewed attention. In the formation of habits and ideals, training in the home and in the group reaches down to the roots of societal life. These phases of brain conditioning are now largely matters of dogmatic tradition or confused instruction.

Our present cult of success dominates formal education. The profound, far-reaching influence of this department of life is exerted through the most effective agencies for adjustment and readjustment. Education is charged with the responsibilities of devising the most beneficial methods for conditioning the brain. It participates in deciding to what ends such conditioning shall be directed and thus occupies a position of supreme control over human behaviour. Its supervision embraces and guides every period of life. Its disciplines have power to shape the character of human intelligence. Its inspirations are the hope of the future. Opportunities are even now at hand for it to overcome its traditional resistances and to open new fields for human satisfaction and contentment. Greater than the power of armies, more compelling than the military force of the entire globe, is the peaceful sway which education may exert in the satisfactory reshaping of existence.

There should be added to these possibilities of future progress the fact that man, in spite of his blemishes, his delinquencies, and failures, is an aspiring and plastic animal. He is not unwilling to take the form of any mold in which he may be cast. He has been the victim of many prejudicial molds—clay in the hands of circumstance. Yet, whatever his form or deformities, he has always aspired to rise above himself. His aspirations have been sublimated in the heroes he has made to admire, in the gods he has selected for worship. Unlike all other animals, he has had the gift of idealization, the power of projecting far ahead of himself, beyond the limits of his recognized imperfections, the ideals of what he hoped or craved to be. Even his societal veneer, his morals, and his manners are products of his aspirations. His idealizations of existence in poetry and art show how tenaciously his vision has dwelt on higher things. Recognition of his own futilities has made him aspire to a future life of purification and redemption. Yet in this aspiring he manifests a lingering childhood, which reveals his still plastic state. The hereafter which he has designed for himself is based on an infantile system of rewards and penalties. This eventual refuge is an acquisitive immortality born of self-interest and bred in self-conceit. It bears the taint of ancient and sordid motives of the race. It has none of the altruism of that more noble and practical immortality through which earthly life strives unselfishly to leave a worthy influence for the benefit of those who later follow the path of human experience.

In the light of his possibilities man's further progress seems assured. Add to these possibilities his remarkable plasticity, his aspiring spirit, his youthful racial development, and it appears inconceivable that he should not advance. Science is constantly placing increased power at his command. While disclosing to him his place in nature, it is also revealing what still remains to be accomplished in the conquest of himself.

Whatever fault may be found with the technique of human living, the major complaint is directed against the persistence of the old objectives. Ancient motives and standards are obstacles in the path of progress. A less complex life is needed—one with new incentives and different goals. Many are living and have lived this kind of life. One among these, the Great Galilean, has made it exemplary. As its influence comes down through the Christian centuries this life brings increasing conviction that it is the best yet lived. One third of the globe's population professes to follow it. As followers they are frustrated in their purpose by the persistence of more ancient influences of the past. Yet it cannot be denied that any order of humanity higher than the present one requires extensive modifications in our purposes, our desires, our outlook on life, our manner of self-expression. A long step in this direction will be taken when the ancient password of the Old Stone Age—*get*, which for thousands of years has been the mainspring of existence, is gradually subordinated by the keynote of a New Golden Age—*give*. This solution of the problem is likely to seem utopian. Long ago we were admonished to try it. If we have failed we need not altogether despair. The human brain has overcome other difficulties to which it has been applied.

With all of its possibilities for improvement, it may in time solve the supremely difficult problem of human nature. Success such as this depends upon the further development of science—especially that comprehensive science which will deal with all of the principles underlying the behaviour of man.

In all respects it is a task of gigantic proportions to build the world anew—to readjust, to recivilize ourselves. At the same time it is the greatest adventure ever conceived by man—to construct his final empire of world coöperation wherein to know and to control himself. Should this be deemed worth while, it must be paid for by the intelligent, unremitting toil necessary to develop the full capacity of our chief reliance—the human brain.

THE END